

CLUB CLASS SAILPLANE WING LOADING AND AIRFOIL DESIGN

Lukáš Popelka⁽¹⁾, Miloš Müller⁽²⁾, Milan Matějka⁽¹⁾, Michal Sedlák⁽¹⁾, Jiří Nožička⁽¹⁾

⁽¹⁾ Department of Fluid Dynamics and Thermodynamics, Faculty of Mechanical Engineering
Czech Technical University in Prague, Technická 4, CZ 166 07 Prague, Czech Republic

⁽²⁾ Department of Power Engineering, Faculty of Mechanical Engineering
Technical University of Liberec, CZ 461 17 Liberec, Czech Republic

Abstract

The article is focused on a sailplane wing sections. Methods of both computational and experimental research are presented. Major types of modern club class sailplanes flown in the Czech Republic are examined, their performance is analysed and a new project of sailplane and airfoils are introduced. An attempt to connect aerodynamic and structural properties of sailplane airframe to the optimization concept is presented.

Motivation

The aim of this project is to establish reliable methods of sailplane aerodynamic analysis. Evaluation and development of up-to-date numerical methods require further refinement of knowledge by means of experimental research. The proper airfoil selection and/or design, behaviour at the stall and during take-off, influence of insect roughness and turbulators are the topical problems.

CFD

Representative test cases are examined, showing the possibilities of Fluent and Xfoil codes. The numerical approaches are verified (Fig. 1) and used for design of wing airfoils (Fig. 2).

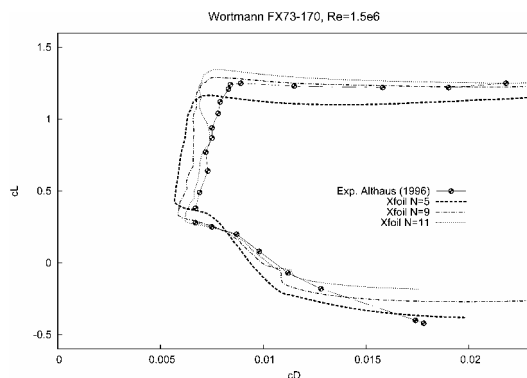


Fig. 1 Measured and calculated polars, Wortmann FX73-170 airfoil, Althaus (1996), Xfoil 6.94

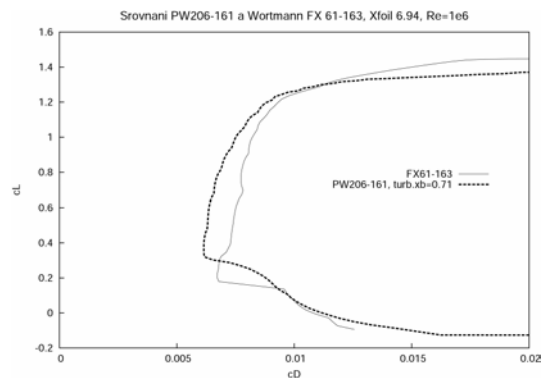


Fig. 2 Comparison of polars, PW206-161 and Wortmann FX61-163 airfoils, Xfoil 6.94

Experimental approach

Wind tunnel testing at the Department of Fluid Dynamics and Thermodynamics CTU FME is focused on measurement of lift, drag and moment loading by means of tensometric balances and surface pressure distribution (Fig. 3), and visualisation using PIV method (Fig. 4). Two main wind tunnels are widely employed (Fig. 5).

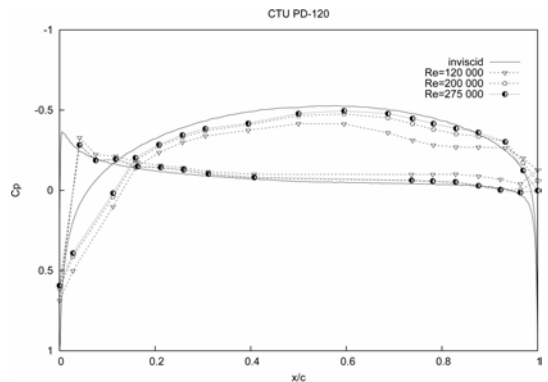


Fig. 3 Measured loading along the chord of CTU PD-120 airfoil

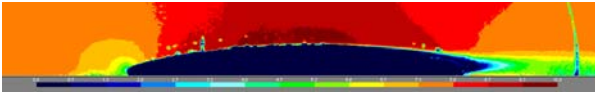


Fig. 4 Measured contours of velocity magnitude [m/s], PIV method, PD-120 airfoil



Fig. 5 Test section of 1200x400mm 2D wind tunnel

Aerodynamic and structural demands

Performance, handling characteristics, strength and stiffness of airframe create conflicting demands. Aerodynamic parameters, such as airfoil thickness, aspect ratio and wing span have strong effect on structural weight and cannot be optimised alone.

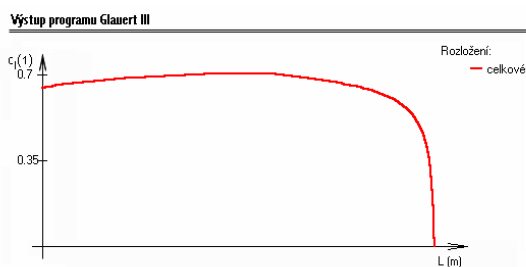


Fig. 6 Wing loading along the span, VSO10 sailplane at lift coefficient 0.67 (corresponding to airspeed 95 km/h), Glauert III software

The club class gliders are used by lower-time pilots and as a transition for students first solo plane. Robust construction is expected.

Conclusions

New airfoils were developed aiming at optimum performance under various in-flight regimes of a club class sailplane, Fig. 7. Verified aerodynamic analysis methods (zonal approach of Xfoil and classic finite span wing theory) proved to be suitable for connection with structural aspects, which will be carried out within the departments involved in Aerospace Research Centre.

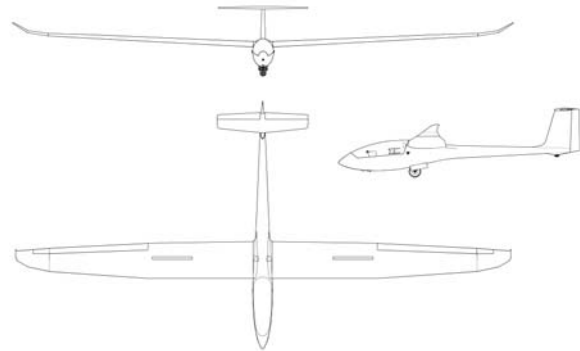


Fig. 7 Project B4, wingspan 15 m

References

- Althaus, D.: *Influencing transition on airfoils*, In: *Technical Soaring*, 1982, vol. 6, no. 12, p. 82-93.
- Althaus, D.: *Niedriggeschwindigkeitsprofile*, 1st Ed. Braunschweig: Vieweg & Sohn Verlagsgesellschaft, 1996. 592p. ISBN 3-528-03820-9
- Boermans, L.M.M., Waibel, G.: *Aerodynamic design of the Standard Class Sailplane ASW-24*, In: *Technical Soaring*. 1989, vol. 13, no. 3, p. 72-83.
- Matějka, M., Popelka, L.: *The role of CFD simulations in preliminary stages of experimental research*, In: *Topical Problems of Fluid Mechanics 2004*, IT CAS Prague, 2004, p. 97-98. ISBN 80-85918-86-2
- Thomas, F.: *Fundamentals of Sailplane Design*, 3rd Ed. College Park Press, 1999. 274 p. ISBN 0-9669553-0-7
- Vaněk, F., Hlinka, J.: *Glauert III software*. 1st Ed. Brno University of Technology, Institute of Aerospace Engineering, 2003. 29 p.