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Aerodynamic optimization of 2-D High-Lift Device under Kinematics constraints

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ABSTRACT

In the aircraft design, development of effective high-lift device (HLD) is one of the most important requirements for the successful design. To be “effective” HLD, better aerodynamic performance with less complexity of the HLD should be pursued. The objective of this study is to develop a practical high-lift devices design system based on Computational Fluid Dynamics and Multi-disciplinary Design Optimization technique.

A three-element airfoil, which has a slat and single slotted flap, is investigated in this study. As for flap kinematics, single straight track such as shown in Fig.1[1] is investigated. When retract and landing positions for flap are given, the lift-to-drag ratio maximization of takeoff position under kinematics constraints are investigated as case studies.

For the kinematics constraints, a simple mathematical model is introduced and evaluated by Genetic Algorithm, then applied to the aerodynamic design space. Fig.2 shows the region of realization of the flap kinematics as the result of evaluation.

Aerodynamic performance penalties due to the kinematics constraints are investigated. Two-dimensional RANS solver with structured overset grid is used for aerodynamic evaluation. Fig.3 shows the computational grid. Totally 300 samples are evaluated through Design of Experiment manner under the constrained case and Genetic Algorithm for unconstrained case, which is conducted for comparative purpose. Fig.4 shows lift-to-drag ratio distributions as a function of flap position in the kinematics constrained case.

Finally, aerodynamic performance penalties due to the kinematics constraints are found to be about 3% through the optimization as shown in Fig.5. Whether the 3% aerodynamic performance penalties are acceptable or not to adopt the kinematics is the design decision. If not, more complex kinematics should be pursued or redesign of landing flap positions should be conducted.

Though what decisions are made is depend on the design situation and the beyond of

the scope of this study, this simple kinematics constraints consideration in the aerodynamic design is found to be very effective and informative for the design efficiency and quality standpoint.

REFERENCES

[1] Rudolph, P.K.C.: High-Lift Systems on Commercial Subsonic Airliners, *NASA CR 4746*, 1996.

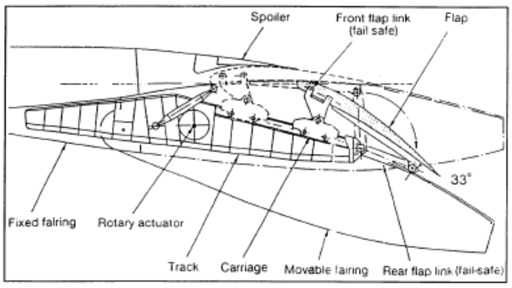

Fig.1 Example of track type (Airbus A330/A340)

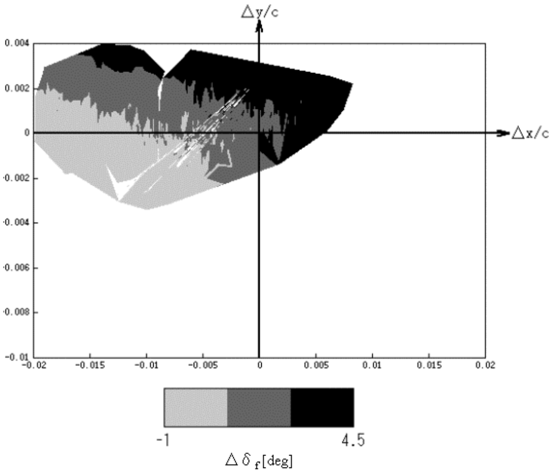

Fig.2 Region for realization of flap kinematics as a function of flap position and deflection

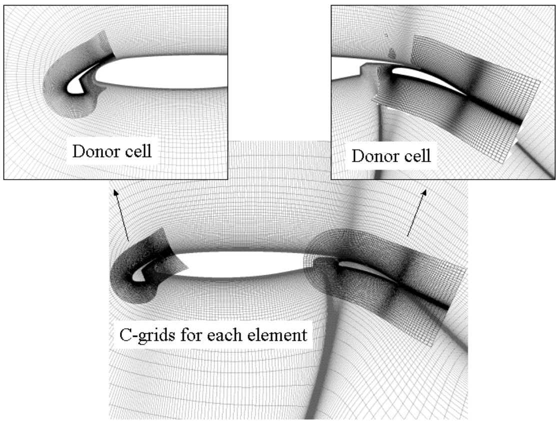

Fig.3 CFD grid and its overlapping pattern for a 3-element airfoil

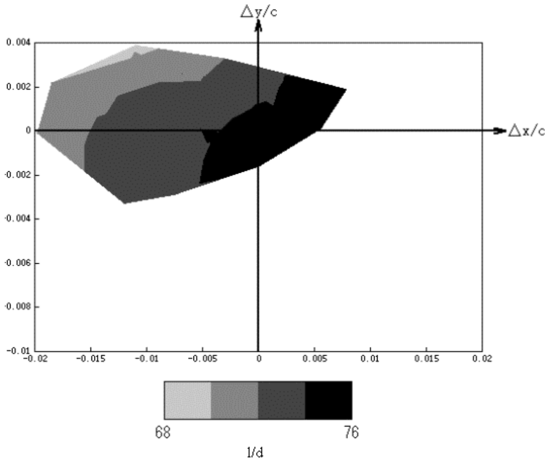

Fig.4 lift-to-drag ratio distributions as a function of flap position in the kinematics constrained case

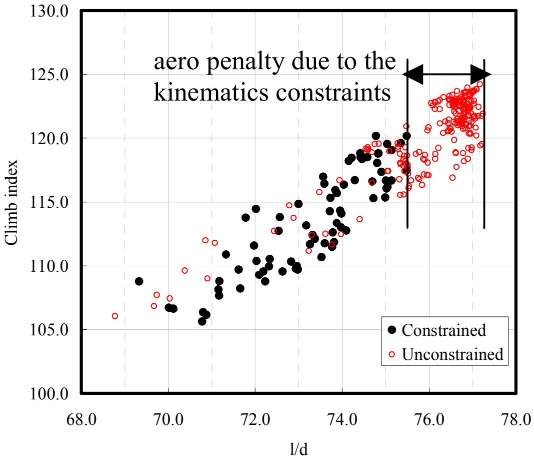

Fig.5 Lift-to-drag ratio panalties due to the kinamatics constraints. (the Climb index $\left(\sqrt{C_l}\times C_l/C_d\right)$ distributions as a function of lift-to-drag ratio)