Mitteilung

Projektgruppe/Fachkreis: Numerische Simulation

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Thema: Automatic Transition Prediction for Unsteady Airfoil Flows Using the e^N-Method

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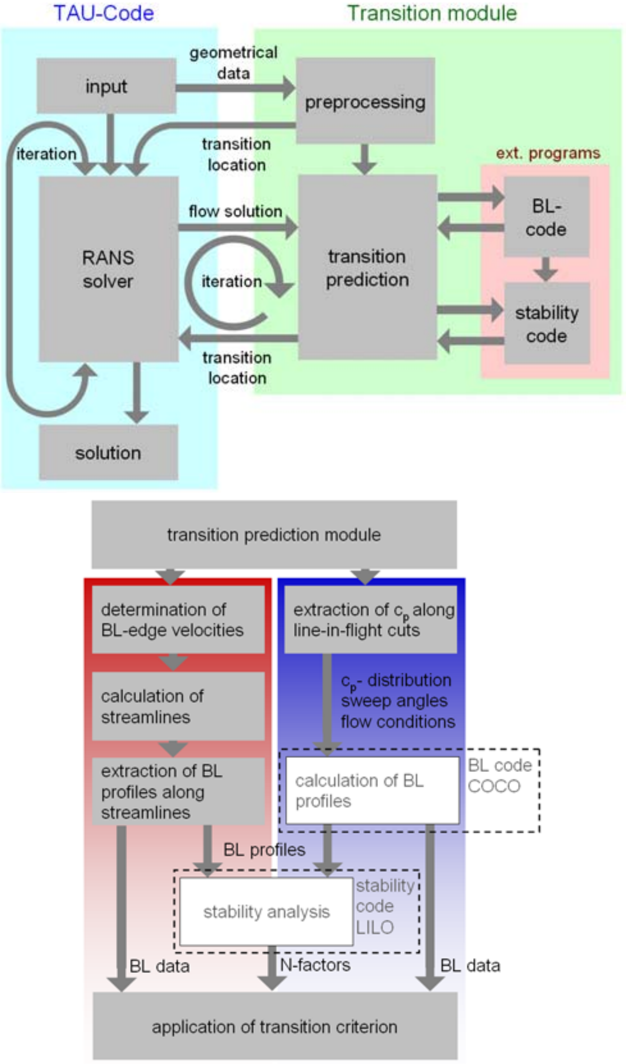


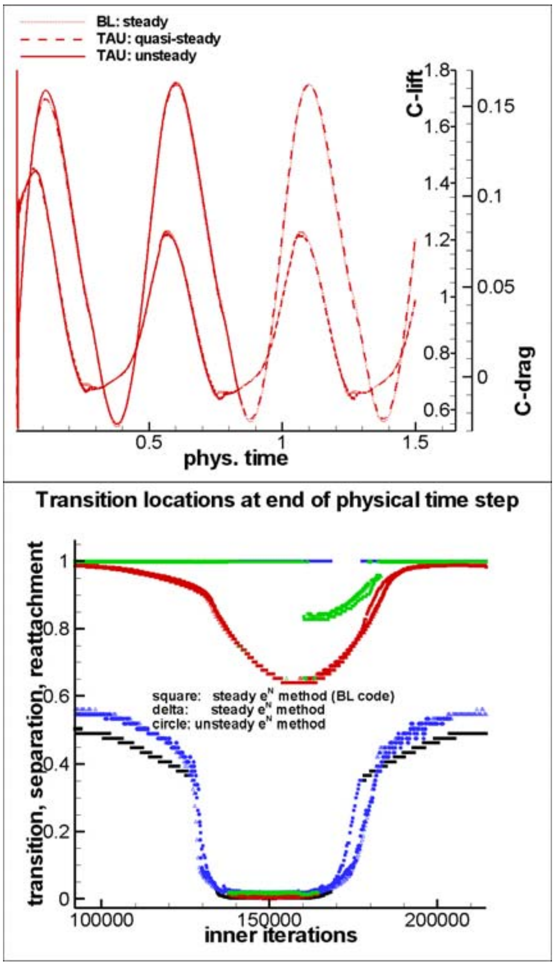
Fig. 1 Coupling and structure of the transition prediction module

Ausgangssituation:
The DLR TAU code has a general transition prediction functionality which can be applied to complex three-dimensional aircraft configurations. The transition module carries out the transition prediction and can be used together with a laminar boundary-layer method for the calculation of highly accurate laminar boundary-layer data. Alternatively, the boundary-layer data can be directly extracted from the RANS solution. A fully automated, local linear stability code analyzes the laminar boundary layer and applies the e^N-method for the determination of the transition points, Figure 1.
The transition prediction functionality has been applied to and its accuracy and reliability have been shown for many steady flow cases. By now, it is intensively used in aerospace industry, for example for wing design.

Ziel:
As the transition prediction in unsteady flows becomes more and more important, the TAU transition prediction functionality must be investigated with regard to its applicability, its performance and its prediction accuracy in time-accurate computations. One research area that has attained special importance in this respect

is the prediction of dynamic stall at the airfoils of helicopter rotors. In order to obtain correct simulation results for oscillating airfoils undergoing dynamic stall the consideration of accurately predicted transition locations during the simulation is crucial.

To assess the transition prediction capabilities of the TAU transition module for this type of flow is the goal of this work.



Transition locations at end of physical time step

Fig. 2 Lift and drag over time (above) and transition, separation and reattachment locations (below) for an oscillating subsonic airfoil flow

Lösungsweg:

The transition prediction functionality of the TAU code has been applied to a number of airfoil flows undergoing a pitch oscillation. The standard e^N-approach using either application mode was applied in a quasi-steady manner.

Additionally, an e^N-based transition prediction approach for flow problems exhibiting unsteady flow[1-3] was implemented into the TAU code[4]. The new method was applied to the same test cases.

Ergebnis:

The results from all transition prediction approaches are presented, compared to each other and, partially, compared to experimental data. In Figure 2, it is shown that for the pitching AS-B airfoil with $M_\infty = 0.15$, $Re_\infty = 2.0$ mio., $T_\infty = 293$ K, $\alpha(t) = 7.0° + \Delta\alpha\ sin\ (\omega t)$, the reduced frequency $\omega^* = \omega c_{ref}/U_\infty = 0.122$, $c_{ref} = c = 1$ m and $U_\infty = 51.5$ m/s the three different approaches yield very similar results with insignificant differences in lift, drag as well as the transition locations. More results for different parameter settings and different configurations are presented in the corresponding presentation and paper.

Literatur:

[1] Windte, J., Radespiel, R., Scholz, U., Eisfeld, B.,''RANS Simulation of the Transitional Flow Around Airfoils at Low Reynolds Numbers for Steady and Unsteady Onset Conditions*", Proceedings of Specialists Meeting on Enhancement of NATO Military Flight Vehicle Performance by Management of Interacting Boundary Layer Transition and Separation, Prague, Czech Republic*, Research and Technology Agency – Applied Vehicle Technology, Neuilly-sur-Seine, France, RTO-AVT-111-P-03, 2004.

[2] Radespiel, R., Windte, J., Scholz, U.,''Numerical and Experimental Flow Analysis of Moving Airfoils with Laminar Separation Bubbles'', *AIAA Journal*, Vol. 45, No. 6, 2007, pp. 1346-1356.

[3] Windte, J., Radespiel, R., ''Propulsive Efficiency of a Moving Airfoil at Transitional Low Reynolds Numbers'', *AIAA Journal*, Vol. 46, No. 9, 2008, pp. 2156-2177.

[4] Hack, P.,"N-Faktor-basierte Transitionsvorhersage für instationäre Strömungen", Diplomarbeit, Technische Universität München, Lehrstuhl für Aerodynamik, 2009.

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