70. Boundary Layer and Stability Methods for Surface Deformations

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An accurate prediction of laminar flow over an aeroplane wing is critical in determining its performance characteristics. Traditionally this is estimated by imposing a locally swept tapered approximation on the flow geometry that enables a 2D strip based approach to base flow and stability analysis. However, the effect of small amplitude deformations in the surface under load can potentially have a large impact on the transition location. The structure of the wing can result in wave-like deformations along both the chord and spanwise directions. Additionally, steps or gaps may be established by the linking of wing components. The various surface deformations can then lead to dramatic three-dimensional changes in the base flow and boundary layer stability that are not correctly captured by the strip method. Fully 3D base flow profiles are generated by either solving the 3D system of boundary layer equations or by directly extracting solutions from RANS computations. The latter method is advantageous as it provides a means of capturing flow profiles in regions that the boundary layer equation method would fail: large adverse pressure gradients that generate flow separation. Stability analysis of fully 3D boundary layers illustrates that there are significant variations in transition, compared with the solutions based on the strip-based approach. Hence, 3D methods are essential for the future analysis of wing performance.

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