Modelling turbulent separated flow in the context of aerodynamic applications

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Abstract

In contrast to rapid advances in computing, numerical methods and visualisation, the predictive capabilities of statistical models of turbulence are limited and improve only slowly, despite much intensive research in the recent past. The intuitive nature of turbulence modelling, its strong reliance on calibration and validation, the extreme sensitivity of model performance to seemingly minor variations in modelling details and flow conditions, and the fact that the non-local dynamics of turbulence are not well captured by single-point closure, all conspire to make turbulence modelling an especially demanding component of CFD, but one that is crucially important for the correct prediction of complex flows. This applies in particular to separation from streamlined bodies, which is, from a computational point of view, the most challenging flow feature in aeronautical CFD.

This paper reviews some aspects of the foundation and application of turbulence models to flows that relate to aeronautical practice, with particular emphasis being placed on turbulence-transport models at a closure level higher than that based on the Boussinesq-viscosity hypothesis. Following a review of basic modelling issues, including aspects of linear-eddy-viscosity two-equation modelling, some recent experience and current work on predicting separation from continuous surfaces with non-linear eddy-viscosity models and second-moment closure are reported. The predictive performance of several anisotropy-resolving models is illustrated by reference to computational solutions for a number of flows, both two- and three-dimensional, some compressible and others incompressible.

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