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TRANSITION LOCATION EFFECT ON SHOCK WAVE BOUNDARY LAYER INTERACTION

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Implicit CFD Method for Transitional Shock Wave – Boundary Layer Interaction

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ABSTRACT

In this paper, the potential of transition prediction methods is explored for modelling transitional shock-wave / boundary-layer interactions. This study is fuelled by the strong interest of researchers and airframe manufacturers in reducing drag of vehicles flying at transonic speeds. The principle of reducing drag via flow laminarity is valid provided there is no need for the flow to sustain large pressure gradients or shocks. This is especially true since laminar boundary layers are less resistant to flow separation. It is therefore worthwhile to assess the performance of CFD methods in modelling laminar boundary layers that can be tripped to turbulence just before the interaction with a shock. For this work the CFD solver of Liverpool is used[1]. The method is strongly implicit and for this reason the implementation of 4-equation intermittency based models[2] requires special attention. Of central importance to the stability and efficiency of the solver is the consideration of the Jacobian needed by implicit methods. In this paper, a strongly implicit method is used where the Navier-Stokes equations, the transport equations of the kinetic energy of turbulence (k) and the turbulent frequency (ω) are inverted at the same time as the transport equations for the flow intermittency (γ) and the momentum thickness Reynolds' number (Re_θ). The result is stable and robust convergence even for complex 3D flow cases.

The method is demonstrated for the flow around the S809 aerofoil as well as for the specially-designed V2C section of the TFAST EU project[3]. Where possible, comparisons of the methods are presented with the e^N method and transition correlations including the methods of Michel[4] or Cebeci. The results suggest that the intermittency based model captures the fundamental physics of the interaction but verification and validation is needed to ensure that accurate results can be obtained. For this reason, comparisons with the TFAST experiments is put forward as a means of establishing confidence in the transition prediction tools employed for shock/boundary-layer interaction simulation.

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