UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF ENGINEERING, SCIENCE & MATHEMATICS

SCHOOL OF ENGINEERING SCIENCES

Doctor of Philosophy

DIRECT NUMERICAL SIMULATION OF A STRAINED AND RECOVERED CHANNEL FLOW WITH REYNOLDS-AVERAGED NAVIER-STOKES MODEL COMPARISONS

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Direct Numerical Simulation (DNS) of $Re_\tau = 390$ and $Re_\tau = 540$ channel flow subjected to the strain and deceleration typical of adverse pressure gradients (APGs) is performed. The statistics satisfy a one-dimensional unsteady problem and contain many of the physical complications which are associated with APGs, thus allowing a straightforward but nontrivial assessment of the models for APG flows, with rigorously defined boundary and initial conditions at an acceptable Reynolds number. The

Re_τ =390 flow subsequently has the deformations removed and is allowed to recover to a steady-state. During the recovery phase the inner region of the flow is observed to recover at a faster rate then the channel core. The results from these flows are then used as experimental data in the performance analysis of eight simple turbulence models. Model accuracy is found to vary significantly, with the Stress-ω stress-transport model giving the best overall result. Two other models tested (Baldwin-Lomax and Launder-Sharma) deviate from the DNS, when exposed to the straining process, in much the same way they do in actual spatially developing APG boundary layers. This supports the relevance of this strained channel idealisation. The DNS results are used to examine the fundamental assumptions of the eight models, casting light on the relevant strengths and weaknesses of each.