UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF ENGINEERING AND APPLIED SCIENCE

SCHOOL OF ENGINEERING SCIENCES

Doctor of Philosophy

A COMBINED NUMERICAL AND EXPERIMENTAL STUDY OF AEROFOIL SEPARATION BUBBLES

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Leading edge separation bubbles on a symmetric thin aerofoil have been studied by several complementary approaches. Experiments were performed in a low-speed wind tunnel using a force balance, pressure tappings and flow visualisation. The objective was to characterize the stall of the aerofoil and to provide measurements of leading edge separation bubbles for validation of predictions using computational fluid dynamics. A full study was made at a Reynolds number 3.2×10^5, where the separation bubble forms at incidences above 5.5^o. The bubble length remains approximately constant as the incidence is increased. The experiments show that the leading edge separation bubble survives the initial lift crisis, which is caused by a rapid upstream movement of the trailing edge separation rather than bubble bursting. Direct numerical simulations of the three-dimensional time dependent compressible Navier-Stokes equations with high-order differencing were performed to investigate the leading edge flow region, with boundary conditions for the simulations taken from an aerofoil panel calculation. The simulation results have been post-processed for mean and turbulence statistics as well as for simpler bubble length and integral quantities. Simulation and experimental data were compared with predictions from two different modelling approaches. Panel/boundary-layer methods did not predict details near stall but did give the correct qualitative behaviour. Reynolds averaged Navier-Stokes calculations required a large number of grid points to resolve the bubbles and had poor convergence near the stall.