PARALLEL URANS SIMULATIONS OF SYNTHETIC JET FLOW FIELDS AND COMPARISONS WITH EXPERIMENTS

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ABSTRACT

In recent years, a promising approach to the control of wall bounded as well as free shear flows, using synthetic jet (oscillatory jet with zero-net-mass-flux) actuators, has received a great deal of attention. A variety of impressive flow control results have been achieved experimentally by many researchers including the vectoring of conventional propulsive jets, modification of aerodynamic characteristics of bluff bodies, control of lift and drag of airfoils, reduction of skin-friction of a flat plate boundary layer, enhanced mixing in circular jets, and control of external as well as internal flow separation and of cavity oscillations. More recently, attempts have been made to numerically simulate some of these flowfields. Numerically several of the above mentioned flowfields have been simulated primarily by employing the Unsteady Reynolds-Averaged Navier Stokes (URANS) equations with a turbulence model and a limited few by Direct Numerical Simulation (DNS). In simulations, both the simplified boundary conditions at the exit of the jet as well as the details of the cavity and lip have been included. In this paper, we describe the results of simulations for several two- and three-dimensional flowfields dealing with the interaction of a synthetic jet with a turbulent boundary layer and control of separation. These simulations have been performed using the URANS equations in conjunction with either one- or a two-equation turbulence model. 2D simulations correspond to the experiments performed by Honohan [1] at Georgia Tech. and 3D simulations correspond to the CFD validation test cases proposed in the NASA Langley Research Center Workshop —"CFD Validation of Synthetic Jets and Turbulent Separation Control" held at Williamsburg, VA in March 2004 [2]. The sources of uncertainty due to grid resolution, time step, boundary conditions, turbulence modeling etc. have been examined during the computations. Extensive comparisons for various flow variables are made with the experimental data; fair agreement is obtained. The computations have been performed on a multi-processor 64-node SGI Origin 2000 supercomputer at Washington University Center for Scientific Parallel Supercomputing (CSPC).

REFERENCES

[1] Honohan, A.M., "The Interaction of Synthetic Jets with Cross Flow and the Modification of Aerodynamic Surfaces," Ph.D. Thesis, Georgia Institute of Technology, May 2003.

[2] Gatski, T. and Rumsey, C., "CFD Validation of Synthetic Jets and Turbulent Separation Control," NASA Langley Research Center Workshop, 29-31 March, 2004. (http://cfdval2004.larc.nasa.gov)