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Introduction: Computational Fluid Dynamics Validation for Synthetic Jets

FLOW control approaches that use synthetic jets have become an important tool for the aerodynamicist. Synthetic jets utilize alternating suction and blowing through a slot or hole to create a boundary condition with zero net mass flux but with momentum transfer to the flow. The synthetic jet is so named because the far-field flow resembles a jet profile that has been "synthesized" from the surrounding flow. The near field, however, is characterized by a disturbance with time-varying oscillatory flow, a transpiration boundary condition near the exit of the synthetic jet, and an oscillatory moving boundary internal to the jet device. Many practical applications of this technology have been demonstrated in laboratory experiments, including jet vectoring, control of separation, enhanced mixing, reduction of wall skin friction, and virtual aeroshaping. With increased use of synthetic jets comes an increasing need for reliable computational tools capable of predicting their effects.

In this special section of the *AIAA Journal*, we are pleased to present a selection of papers that arose from the CFDVAL 2004 Workshop held in Williamsburg, Virginia, in March 2004. This workshop focused on CFD Validation of Synthetic Jets and Turbulent Separation Control. Some of these papers were also subsequently presented at the 2nd AIAA Flow Control Conference held in June–July 2004 in Portland, Oregon.

In the CFDVAL 2004 Workshop, a series of three experiments, conducted at the NASA Langley Research Center, were used as test cases for CFD validation. These experiments spanned a range of geometries and flowfield conditions. In case 1, a synthetic jet issued from a thin slot into a quiescent flow. The resulting flowfield was nominally two-dimensional near the centerplane of the slot exit. In case 2, a synthetic jet issued from a circular orifice into a turbulent boundary layer, creating a three-dimensional interaction. In case 3, the separated flow over a nominally two-dimensional wall-mounted hump was investigated using three boundary conditions applied at a slot located in the pressure recovery area. The three boundary conditions included no suction or blowing, steady suction, and a synthetic jet.

The test cases described created challenges for both experimental measurements and computational simulations of the time-varying flowfields. A variety of experimental measurement techniques were used in the investigation of these flows, and a variety of computational approaches were used in the simulations of the flows as well.

The seven papers presented in this special section include a summary paper of all of the results from the workshop, along with six specific CFD contributions. These six CFD papers provide a broad cross section of state-of-the-art methodologies, including reduced-order modeling, Reynolds-averaged Navier–Stokes (RANS), detached-eddy simulation (DES), large-eddy simulation (LES), and direct numerical simulation (DNS). All three of the test cases are represented by this set of papers.

We are pleased to be able to share these contributions to the flow control literature with you. It is hoped that the publication of this special section will encourage further submissions on this topic, especially those providing data for validation studies.

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