DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING SEMINAR
University of Virginia, Charlottesville, Virginia

COMPREHENSIVE LDV MEASUREMENTS FOR IMPROVEMENTS TO HIGH REYNOLDS NUMBER AND HIGH-SPEED 3-D TURBULENT FLOW MODELS

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Time: October 4, 2007
Place: MEC 341, Mechanical Engineering Building
Refreshments at 3:30 PM in MAE Faculty Lounge, MEC 305

Abstract

In this research program, a new comprehensive laser-Doppler velocimeter (CompLDV) experimental technique was developed and used to measure the instantaneous vector velocity, acceleration, and position of multiple particles within the Kolmogorov scales of high Reynolds number low-speed turbulent boundary layer flows (28mps). With at least 4 particles at a given instant this results in the fine-spatial-resolution instantaneous measurement of the complete rate-of-strain and vorticity tensors and the dissipative and velocity fluctuation-pressure gradient fluctuation correlation terms in the Reynolds-averaged equations for complex three-dimensional turbulent flows, without employing any assumptions. Many improvements to LDV technologies were made, including use of converging and diverging fringe patterns over a 200 micron diameter volume, greater signal-to-noise ratio signals, and advanced signal processing. The resulting data for all quantities have lower uncertainties and are obtained at rates up to 100,000Hz. Currently there is no other such experimental technique available and experimental information on both the dissipation rate and velocity fluctuation-pressure gradient fluctuation correlation terms in the Reynolds-averaged stress transport equations at high Reynolds numbers is important for improved turbulence modeling of complex 3-d flows, like those in gas turbines and separated and vortical flows. During 2002 – 2006, the technique was used to obtain data for: (1) three-dimensional turbulent boundary layers and vortical and separated flows similar to those in gas turbines, with and without high free-stream turbulence levels, and (2) rough-wall boundary layers, which are also of interest to gas turbines.

The CompLDV technologies are now mature enough to be applied to high flow speed problems. Combined with the proven and refined laser-induced fluorescence (LIF) technique to measure the particle temperature, and the proven and refined filtered Rayleigh scattering (FRS) method to measure the gas density, low uncertainty information at a high data rate (>0.5MHz) for high speed test flows is feasible and can be obtained in research that just started with funding from new grants.