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Research stays strong for aero measurements

BY DAVID PLEMMONS AND TOM JENKINS

The **Aerodynamic Measurement Technology Technical Committee** advances measurement technology for ground facilities and aircraft in flight.

The wind tunnel team at Sandia National Labs continues this year to advance its time-resolved **particle image velocimetry**, or PIV, capability using a pulse-burst laser. In its most recent configuration, measurements have been achieved at an astounding 400 kilohertz though restricted to a small field of view — which therefore has been dubbed "postage-stamp PIV." More than 4,000 sequential vector fields can be acquired. This unprecedented framing rate is well-suited to measuring turbulent velocity spectra in high-speed flows and is being used to improve the physical models underlying aerodynamic simulations.

The new HORIZON research group — High-speed Original Research and Innovation Zone — at The University of Tennessee Space Institute has been exploring the use of high-speed Schlieren imaging as an alternative to conventional dynamic surface pressure measurements in the characterization of unsteady **transitional shock wave and boundary layer interactions**, or XSWBLI. In one of the first studies of its type, the group is post-processing large data sets of images to build statistical models for the interaction dynamics of XSWBLI in a manner similar to that developed for turbulent interactions using dynamic pressure transducers in the past.

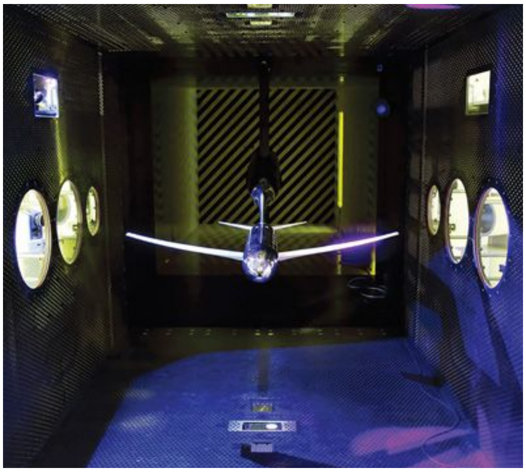
North Carolina State University has developed a laser-based combustion diagnostic technique to measure gas-phase temperature and pressure that does not require any knowledge of the local composition of gases. This is a new method that makes use of spectral line broadening of a seeded or naturally present absorbing species in the flow field. The university's preliminary evaluation of the method has been demonstrated in an atmospheric CH_4/N_2 laminar nonpremixed flame. Uncertainties of about 12 percent have been demonstrated for both temperature and pressure. These results demonstrate a strong potential for developing this method to a robust technique for realistic flow environments.

Diagnostics that can resolve the 3-D structures of highly turbulent flames have long been desired. Researchers at Virginia Tech and the Air Force Research Laboratory recently demonstrated 3-D combustion measurements based on a technique named VLIF, or **volumetric laser induced fluorescence**. The 3-D VLIF measurement technique has been validated by comparing cross sections of VLIF images to coincident planar LIF images acquired with an independent camera. The close overlap observed demonstrates the fidelity and accuracy of the VLIF technique to provide instantaneous 3-D measurements of turbulent flames. The VLIF technique will be used in future tests to resolve 3-D structures of highly turbulent flames and provide key combustion properties such as flame front location, surface area, volume and curvature.

Researchers at the Air Force Research Laboratory, Aerospace Systems Directorate and the University of Tennessee demonstrated rotational temperature measurements through ceramic materials in a cylindrical flow reactor and toroidal well-stirred reactor by utilizing see-through-wall coherent microwave scattering from **Resonance Enhanced Multiphoton Ionization** of molecular oxygen.

Gas temperatures inside the reactors have been measured with an uncertainty of 3 percent. For gas temperatures of 800 degrees Fahrenheit, or 700 Kelvins, this amounts to an accuracy of approximately plus or minus 20 Kelvins. This technique shows great potential for noninvasive, high-fidelity quantification of spatially localized temperature in combustion kinetic experiments and confined combustors constructed of advanced ceramic materials in which limited or nonexisting optical access hinders usage of conventional optical diagnostic techniques to quantify thermal nonuniformity.

The Japan Aerospace Exploration Agency and Tohoku University in Sendai, Japan, have conducted unsteady **pressure-sensitive paint**, or PSP, measurement tests to investigate the transonic buffet on the 80 percent scaled NASA Common Research Model. The main wing of the model was painted with fast-response PSP having negligible surface roughness effects and illuminated by a high-power violet LED. Unsteady PSP images were captured at the rate of 5 kHz. The time-series pressure maps clearly showed the dynamic behavior of the transonic buffet on the main wing. ★



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A scaled NASA Common Research Model is installed in the Japan Aerospace Exploration Agency's 2-meter by 2-meter transonic wind tunnel for tests that include unsteady pressure sensitive paint.