

Aerodynamic measurement technology

Researchers at Michigan State, in collaboration with MIT and Iowa State, have introduced the use of quantum dot (QD) nanoparticles for measurements in fluid flows. Measurement capabilities include characterization of scalar concentration and temperature distributions using QD tracers, in addition to imaging single QDs for near-surface velocimetry.

NASA Langley researchers are using high-resolution, 1-kHz-rate video cameras to track the motion of falling crew exploration vehicle (CEV) test articles in support of the Orion Constellation program. A frame-by-frame object-to-image-plane scaling procedure is being applied to help capture the dynamic impact of the vehicles before, during, and after ground contacts. Calculations are furnished for vehicle displacement, pitch and yaw angle changes, and vertical and horizontal velocities of the CEV models. Photogrammetric data obtained during testing, along with other instrumentation onboard the drop vehicles, helps validate computations.

Stanford University is investigating two new classes of diode-laser-based sources for wavelength-tunable light in the mid-IR. The wavelength-tunable 3.30- μm lasers are based on difference-frequency conversion of two

fiber-amplified diode lasers in periodically poled lithium niobate. The wavelength tunability enables diverse new strategies to suppress noise and background signals in harsh combustion and propulsion environments. Advances in optically active materials have also enabled extension of tunable diode lasers to wavelengths in the range 2.3-2.7 μm , enabling extension of diode laser sensing strategies to the stronger absorption features of the CO_2 and H_2O combustion products. These stronger transitions offer potential for precise measure-

ments of lower concentrations, shorter optical paths, and improved time resolution.

Also at Stanford, research into the ignition chemistry of practical fuels and propellants, such as JP-8, JP-10, and DF-2, requires specialized laboratory test facilities to overcome the low room temperature vapor pressures of these substances, where the real possibility of pretest decomposition and oxidation of the fuel exists. To circumvent this problem, a new method for studying low-vapor-pressure fuels has been developed. A liquid fuel aerosol is introduced into a shock tube, and the heat-rise from the incident shock wave vaporizes the aerosol, rapidly producing a controlled mixture of fuel vapor. The high-temperature-ignition chemistry of the fully vaporized fuel can be studied behind the subsequent reflected shock wave.

This method provides complete and rapid conversion of fuel to vapor phase *without pretest fuel decomposition and oxidation, and complete control of the mixture* and test conditions—pressure, temperature, and equivalence ratio. Laser absorption is used to measure time-histories of the concentration of a wide variety of chemically important species: fuel components (alkanes, aromatics) are measured in the mid-IR using difference frequency generation lasers; transient radical species (OH, CH_3) are measured in the UV using frequency-doubled and -quadrupled lasers; products (CO , CO_2 , and H_2O) are measured using near-IR and mid-IR tunable diode lasers; and aerosol droplet loading is measured with nonresonant near-IR laser extinction. Using the aerosol shock tube and its laser-based diagnostics, fundamental chemical processes of jet fuels, jet fuel surrogates, and new synthetic fuels such as Fischer-Tropsch fuels can be studied at elevated temperatures and pressures.

Vanderbilt University, Arnold Engineering Development Center, and the University of Tennessee Space Institute conducted the first demonstration of hydroxyl tagging velocimetry (HTV) in a gas turbine exhaust, operating a GE J85 engine from idle to full throttle. HTV is a laser-based nonintrusive technique that photodissociates water vapor (H_2O) in the exhaust into OH and H using a grid of ultraviolet pulsed laser beams.

The resulting OH grid “written” in the flow is subsequently “read” by imaging the grid’s OH fluorescence utilizing another ultraviolet pulsed laser sheet. Flow displacement measurement through grid image comparisons and knowledge of the write-read delay time provide instantaneous velocity field data. Exhaust velocities up to 500 m/sec (1,100 mph) were measured.

J85 engine at UTSI shows HTV laser flow tagging optics at exit. The red lines indicate grid-writing laser path; blue indicates PLIF “read” laser sheet.

