PDPA MEASUREMENTS OF AIRCRAFT ENGINE COMBUSTOR

APPLICATION NOTE PDPA-006

In this time of rising petroleum prices and concern for noise and pollutant emissions, it is becoming more important than ever to achieve clean efficient combustion in aircraft engines. In the past it may not have been cost-effective or necessary to conduct careful in-situ measurements, but with today's high-performance optics and signal processors, phase Doppler measurements can be done in operating aircraft engine combustor rigs. Such facilities are at work at the Ben T. Zinn Combustion Laboratory at Georgia Institute of Technology in Atlanta Georgia.

The Ben T. Zinn Combustion lab utilizes a 2D PDPA, equipped with a 5W laser, FBL-2 fiberlight™ beam generator, and TM250 transmitter probe equipped with optional beam expander. Signals are captured by a RV2070 receiver and sent to a PDM1000-2P detector module. An FSA 4000-2P signal processor and FLOWSIZER™ software are used to capture and analyze the data. Key processor features, such as dynamic sampling rate selection, burst centering, SNR-based burst detection, and intensity validation enabled the PDPA to make accurate and detailed measurements on this challenging combustion environment.

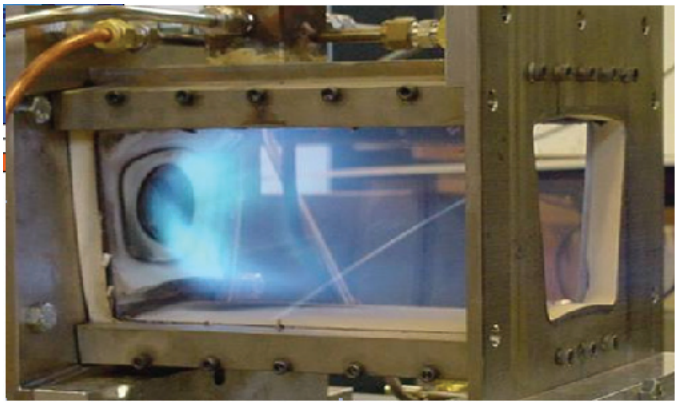

Figure 1: Combustor in operation, showing the test section, windows, and premix burner exit.

Courtesy Jonathan Colby and Georgia Institute of Technology

Lean combustors typically operate in a multi-stage configuration, separated by elements such as swirl inducers, air injectors, and/or flame stabilizers. Initial combustion may be rich, or, a vaporization zone may be followed by one or more combustion zones. One quickly realizes that spray dynamics plays an important role in the stable reliable operation of such a combustor. That's where the PDPA comes in.

The PDPA was designed to measure droplet size, velocity, concentration, flux, and a host of diameter statistics like the Sauter mean diameter and various volume mean diameters. Results from the combustor of Figure 1 are indicated in Figure 2 as a normalized Sauter mean diameter plot. We notice that the larger droplets penetrate further into the lean

zone at the outer periphery. Regions of larger droplets appear to meander and are not symmetric about the axis. The core region did not contain any measurable droplets of 0.5 µm diameter or larger. More results can be found in AIAA papers AIAA-2005-4143 and AIAA-2006-4919.

Certain unique issues arise with combustion flow measurements, and user experience is most valuable in dealing with these matters. Consultation with TSI and other expert users at conferences/trade shows is the best way to build your knowledge base. The above results illustrate some of the observations one can obtain with a TSI PDPA.

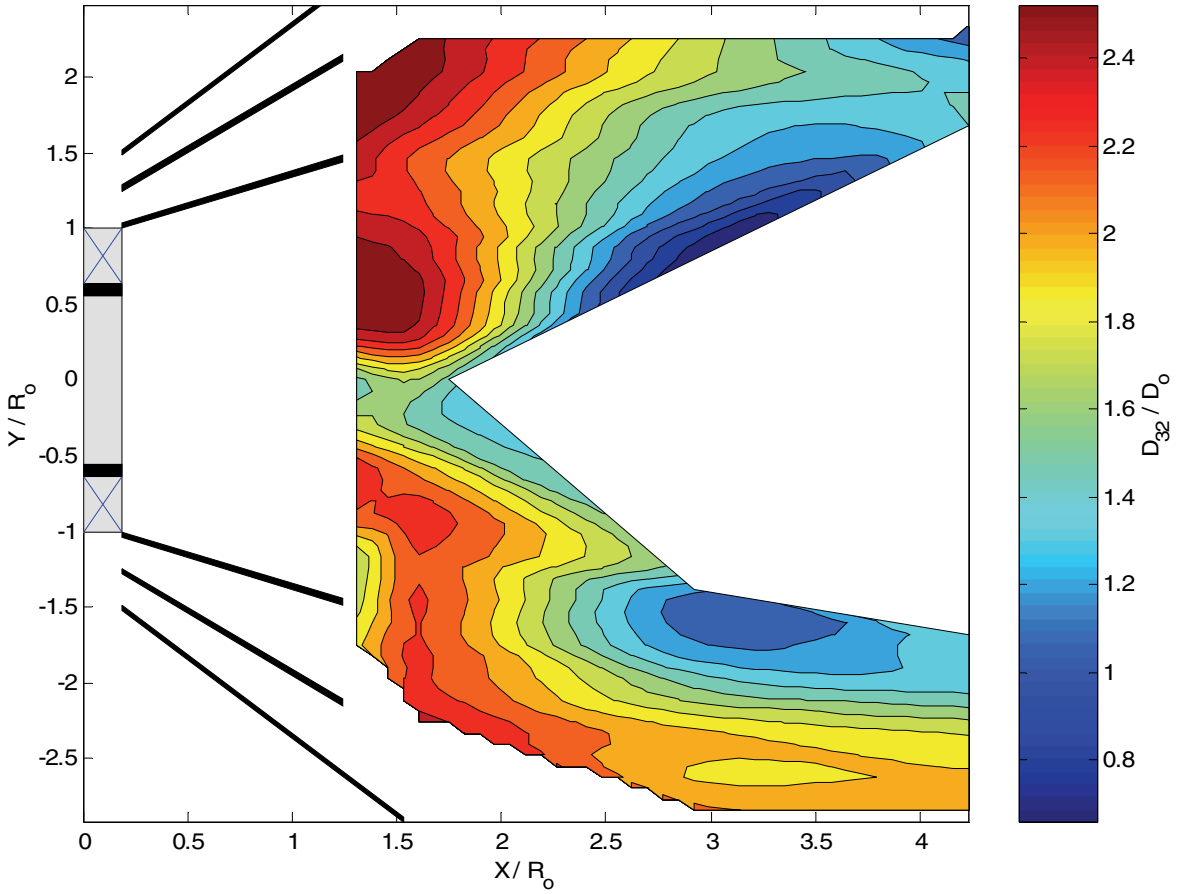

Figure 2: Measured Sauter Mean Diameter (normalized) for an operating gas turbine engine combustor.

Courtesy Jonathan Colby and the Georgia Institute of Technology. For further details see AIAA-2005-4143 and AIAA-2006-4919.

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