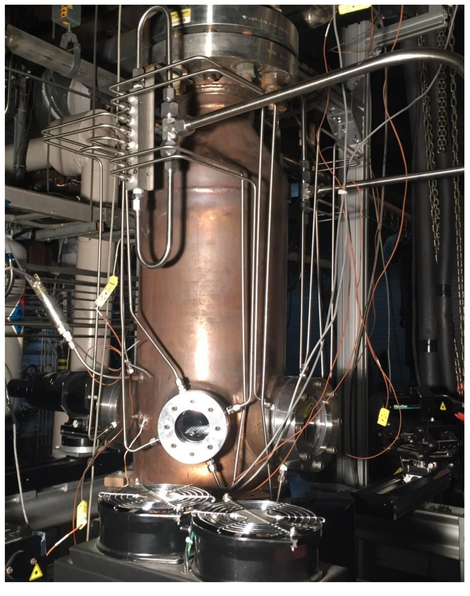
NJFCP Project 29A
Atomization Test and Models

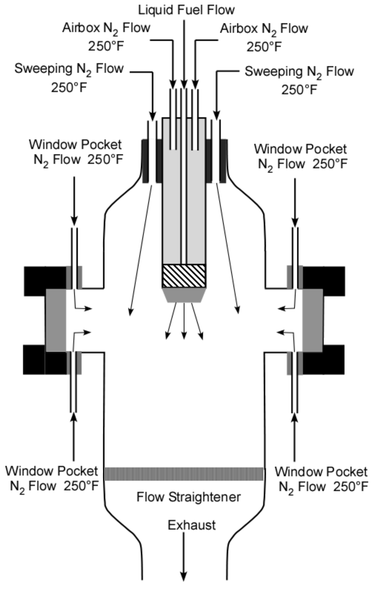
Motivation and Objectives

- Perform detailed diagnostic investigations of spray properties (e.g. fuel droplet size distribution, fuel spray break up length, cone angle) for a selected range of alternative fuels and operating conditions.
- Use advanced diagnostics such as phase Doppler anemometry (PDA). Investigate wide range of operating conditions (e.g., fuel temperature, fuel pressure, swirler pressure drop) using the unique Variable Ambient Pressure Spray rig. Investigate Area 6 referee rig nozzle and Pratt & Whitney/Georgia Tech Area 3 nozzle.
- Interact closely with Stanford group (Area 5, Project 29B) and UTRC group who are performing advanced spray modeling, UDRI group (Area 6) that is operating the referee rig, and Georgia Tech group (Area 3) investigating fuel effects on combustion.

Methods and Materials

Variable Ambient Pressure Spray (VAPS) rig was designed for spray measurements at chamber pressures from 0.3 to 30 atm. PDA and diffraction methods (e.g. Sympatec) can be applied for droplet size and velocity measurements.



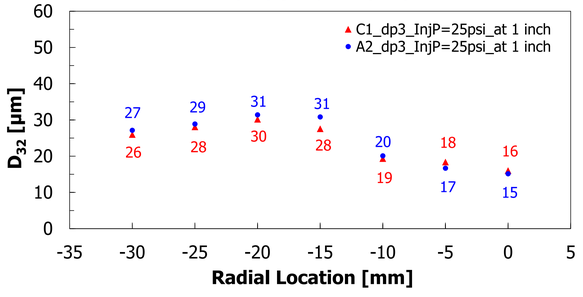


Summary

Researchers at Maurice J. Zucrow Laboratory/Purdue University are collaborating with Matthias Ihme of Stanford, Nader Rizk, formerly of Rolls Royce, Suresh Menon of GT, Vaidya Sankaran of UTRC, Jeff Lovett of P&W, Andrew Corber of C-NRC, and other team members of the National Jet Fuel Combustion Program (NJFCP) to conduct atomization and spray measurements. The measurements below were performed on the referee rig nozzle at LBO conditions.

PDA Sauter Mean Diameter (D_{32}) Measurements from the VAPS rig at LBO Conditions for Different Fuels

D_{32} Comparison Between C1 and A2 at LBO conditions



The LBO operating conditions presented are at an ambient pressure within the vessel of 2.07 bar (30 psia), an air box nitrogen temperature of 394 K (250ºF), a pilot fuel temperature of 322 K (120ºF), a pilot fuel mass flow rate of 9.22 kg/hr (20 lbm/hr), and an injection pressure differential of 1.72 bar (25 psia).

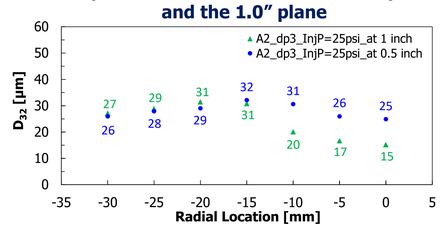
Lead investigators: Robert Lucht, Jay Gore, and Paul Sojka, Purdue University

Project manager: Aniel Jardines, FAA and Mohan Gupta, FAA (on assignment to DOE)

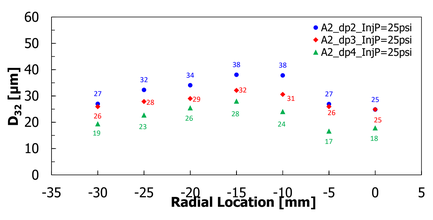
Results and Discussion

- Continuing to work through test matrix developed by Nader Rizk for development of spray correlations for different fuels and to define ICs and BCs for LES models
- Further investigating fuel effects using refurbished PDA system with increased laser power
- Investigating spray at different measurement planes relative to the exit of the swirlers
- Confirmed ability to prevent window obscuration when spraying cold fuel at fuel temperature of 239K (-30ºF)

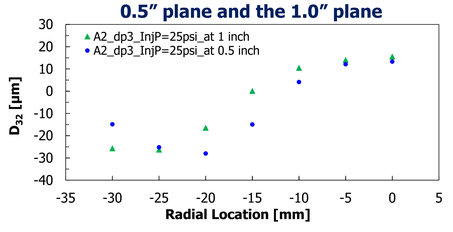
Comparison of D32 between the 0.5" plane and the 1.0" plane



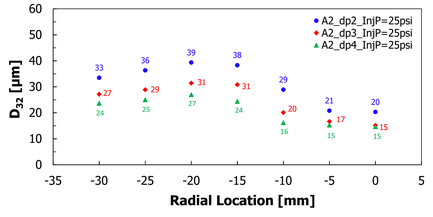
ΔP/P Variation Results at 0.5" plane



Comparison of Axial Velocity between the 0.5" plane and the 1.0" plane



ΔP/P Variation Results at 1" plane



Conclusions and Future Steps

- *Minimal variation in D_{32} between C1 and A2 at LBO operating conditions*
- *Less D_{32} variation between the center and edge of the spray for the 0.5" plane compared to the 1.0" plane*
- *Comparison of PDA data with LES spray models*
- *Finish remaining LBO condition testing at additional measurement planes*
- *Performing initial PDA measurements of chilled fuel tests at ambient pressure within the vessel*
- *Installation of an air ejector on the end of the VAPS vessel will reduce the pressure to sub-atmospheric conditions for high-altitude relight testing conditions*

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