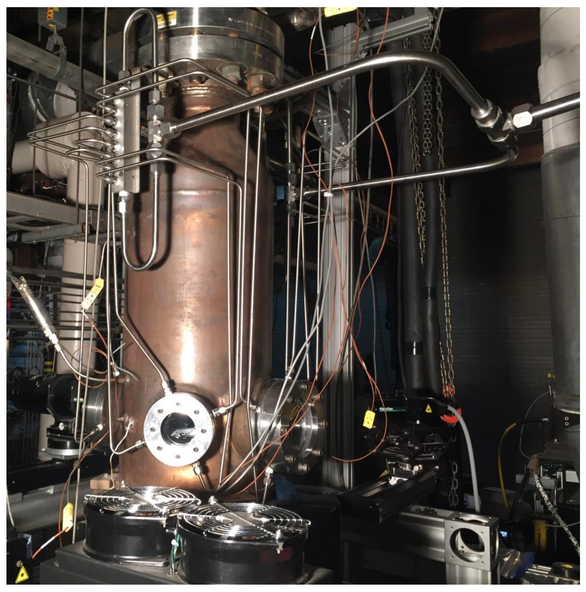
NJFCP Project 29A
Atomization Test and Models

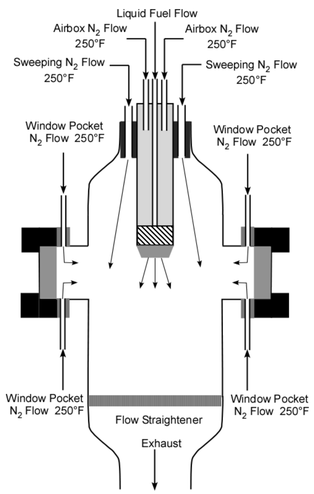
Motivation and Objectives

- 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 Rules and Tools spray test 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 in combustion.

Methods and Materials

Rules and Tools spray (RTS) test rig was designed for spray measurements at chamber pressures from 0.3 to 30 atm. PDA and diffraction methods (e.g. Sympatec) applied for droplet size and velocity measurements.

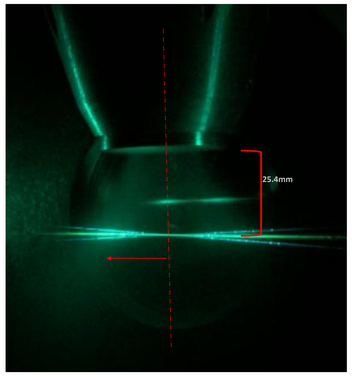


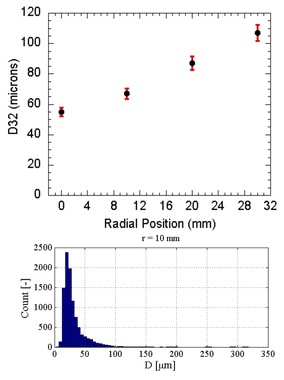


Summary

Researchers at Zucrow Laboratory at Purdue University are collaborating with Matthias Ihme of Stanford, Nader Rizk, formerly of Rolls Royce, Suresh Menon of Georgia Tech, Vaidya Sankaran of UTRC, Jeff Lovett of Pratt & Whitney Andrew Corber of NRC Canada, and other team members of the National Jet Fuel Combustion Program (NJFCP) to conduct atomization and spray measurements using two nozzles: one designed by Parker Hannifin for the Rules and Tools program (supported in the past by the U.S. Air Force Office of Scientific Research) and one used in combustion tests at Georgia Tech (Area 3) with a swirler designed by Pratt & Whitney. We are also working in close collaboration with major engine OEMs.

PDA drop size pdf and Sauter mean diameter (D_{32}) measurements in the RTS rig at LBO Conditions





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Project manager: Mohan Gupta, FAA

Results and Discussion

- Extensive testing of alternative fuels using PDPA and high-speed video imaging. Measurements performed using referee nozzle, also being used in Area 6 referee test rig. Investigated A-2, C-1, and C-5 fuels over wide range of operating conditions:
  - Fuel temperature: -30ºF to 60ºF, pressure drop 25 psid to 100 psid
  - Swirler pressure drop $\Delta p/p$: 2% to 8%
- Spray quality decreases (D_{32} increases) with decreasing temperature
- Swirler pressure drop has most significant effect on droplet size distribution
- Rules and Tools Rig modified for operation at lean blow-out (LBO) conditions (air temperature 250ºF, fuel temperature 126ºF, 30 psia, 3% $\Delta p/p$ across swirler), detailed PDA measurements at LBO conditions are in progress

Conclusions and Next Steps

- Extensive testing in Rules and Tools Spray (RTS) test rig at LBO conditions for A-2, C-1 and C-5 fuels, provide data for input to LES modeling (Ihme and Menon groups).
- Both Area 6 referee rig swirler and Pratt and Whitney swirler with two different nozzles will be investigated.
- Continue to work through test matrix developed by Nader Rizk for development of spray correlations for different fuels
- Chilled nitrogen system will be developed so that high-altitude relight measurements with a chilled swirler flow can be performed – swirler nitrogen temperatures down to from -30º F, pressures down to 4 psia can be achieved in RTS test rig
- More fuels (A-3, C-3, C-6) will be investigated
- Mie scattering and fuel PLIF imaging will be performed in the Advanced Gas Turbine Combustion test rig under reacting (heated air flow) and nonreacting (heated nitrogen flow) conditions in Year 3

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