EXPERIMENTAL INVESTIGATION OF ATOMIZATION AND COMBUSTION BEHAVIOR OF RENEWABLE FUELS

MOTIVATION

- Biodiesels are possible low carbon alternatives for use in gas turbines.
- Differences in physical properties from conventional diesels present challenges to the atomization quality for biodiesels which can lead to increased NO_x emissions.
- Strategies are desired that will enable use of low carbon fuels while conserving atomization performance.

GOAL

- Develop strategies to improve atomization, as well as robust fuel blends that exhibit low emissions output.

APPROACH

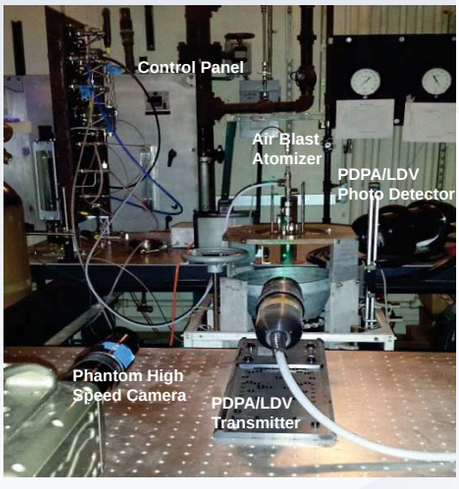
- Measure physical properties for the alternative liquid fuels.
- Determine detailed spray behavior using phase Doppler interferometry.
- Compare atomization performance for renewable fuels with that of conventional diesels.

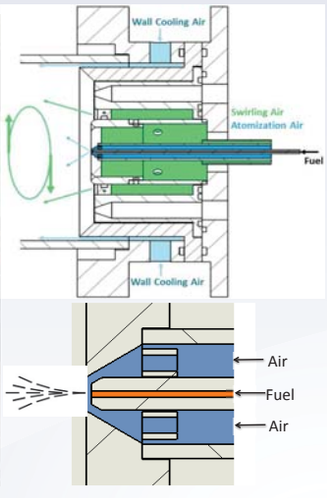
EXPERIMENT

- The following fuels are injected by an air-blast atomizer under identical theoretical power outputs and air mass flow rates[F1].
- Velocity and size data for 3 atomizing air pressure drops.

Fuel	Approx. Chemical Formula	Flow Rate ml/min
F-76 Navy Distillate	$C_{14.64}H_{30.4}$	4.06
DF2	$C_{15.43}H_{32.22}$	4.10
F-76/Algae Blend	$C_{15.95}H_{33.05}$	4.19
Methanol	CH_3OH	9.12
Ethanol	C_2H_5OH	6.79
B99	$C_{18.76}H_{34.58}O_2$	4.43

- Create a variety of B99-Ethanol blends and obtain the data on density, viscosity, surface tension[F2].





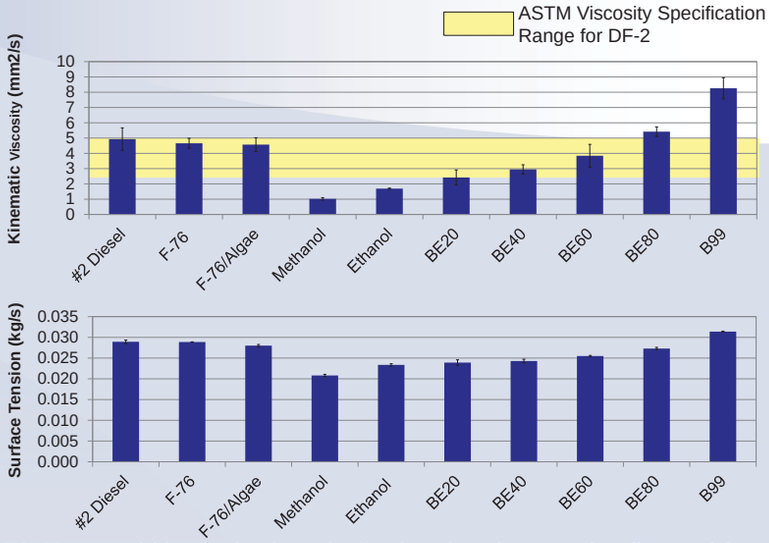
F1: Clockwise from Left: Experimental Setup, Cross Section View of Air blast Atomizer, Close Up of Atomizer Nozzle

DIAGNOSTICS

- TSI FSA-4000 Phase Doppler Particle Analyzer (PDPA) coupled with a Laser Doppler Velocimeter (LDV)
- Vision Research Phantom 7.1 high speed camera

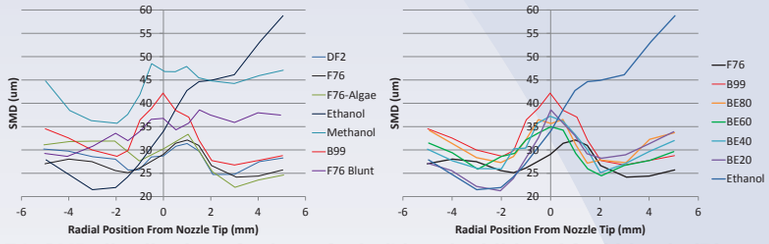
RESULTS

- High speed shadowgraphy captures atomization stills in which all four fuels can be qualitatively contrasted[F3].
- SMD profiles are plotted as point measurements across the spray plume detailing symmetry and asymmetries[F4].
- Weighted overall SMD values weighed against predicted values based on Rizk and Lefebvre's correlation for air-blast atomizers[F5].
- B99-ethanol blends display smaller droplet sizes for lower air-to-liquid ratios (ALR) up to 40% ethanol blends[F5].

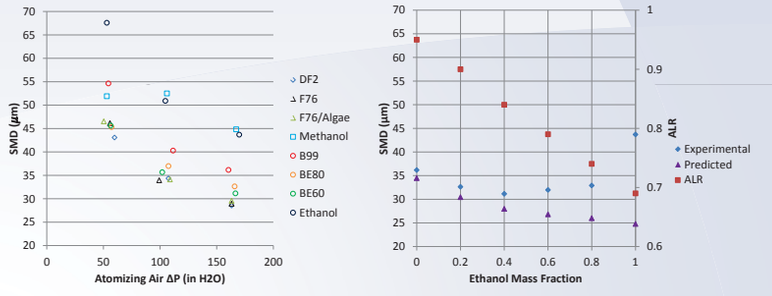


F2: Measured kinematic viscosity (top) and surface tension (bottom) for all fuels and blends

F3: High Speed Images (L > R): F-76, BE60, Ethanol, Methanol



F4: SMD distributions for base fuels (L) and additional fuel blends (R)



F5: Weighted SMD values for all fuels (L) and for fuel blends compared with predicted values (R)

CONCLUSIONS

- Blending of B99 and ethanol leads to improved atomization quality among renewable fuels.
- Baseline fuels achieve superior atomization than biofuels, regardless of blending strategy.
- Future reacting tests will determine how biodiesel compositions and atomization quality impact emissions behavior.

RECENT PUBLICATIONS & PAPERS

A.G. Silver, V.G. McDonell and G.S. Samuelsen, Experimental Investigation of Atomization Behavior of Renewable Biofuels, Proceedings of ILASS Americas, 27th Annual Conference, Portland, Oregon, USA May 18-21, 2014.

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