ALTERNATIVE FUELS

Biodiesel | Ethanol

OVERVIEW

Liquid fuels from bioderivative and waste sources allow for an attractive alternative strategy, providing a cleaner, high energy density fuel stream with a very low carbon footprint. Currently, in small-scale applications, reciprocating engines are commonly used, which exhaust considerable amounts of criteria pollutants. Small scale gas turbines, which present a reliable, high efficiency and cleaner option can provide a feasible replacement for existing remote and backup power generators. The current UCI study addresses the role of fuel preparation and its impact on engine performance and emissions in a 30kW gas turbine for soy biodiesel and ethanol fuels in comparison to the engines designated fuel, low sulfur diesel.

GOALS

The UCI study's focus is to (1) determine the chemical makeup and liquid properties for the fuels of interest, (2) fundamentally understand the role of plain-jet airblast atomization and vaporization during the fuel preparation process for these fuels, and (3) explain the fuel preparation process's impact on engine performance and exhaust emissions.

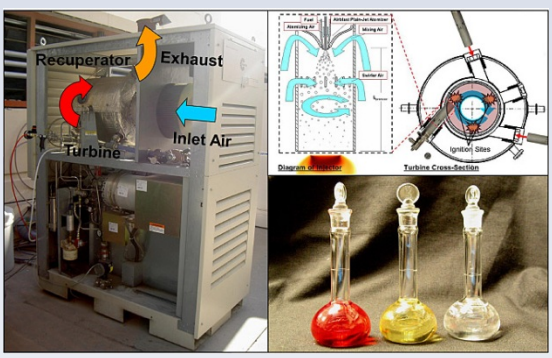

Figure 1: (Clockwise from Left) (a) Small scale gas turbine Capstone model C30 with direction of engine air flow overlaid (b) Cross-section of engine and fuel injector with air flows provided (c) Photograph of low sulfur diesel #2, soy biodiesel (B99) and neat ethanol fuels

RESULTS

Sustained operation of a commercial gas turbine fueled with B99 was demonstrated. This simple switch in fuel streams produced an increase in NOx emissions, wear due to raw/coked fuel deposited on the injection hardware and issues with an incomplete fuel purge during shutdown (due to B99's higher viscosity). Atomization performance in the fuel injection system compared well with the airblast atomization theory proposed by Rizk and Lefebvre.

RESULTS (CONT.)

Modifying the engine to improve the atomization quality by increasing air flow at the point of injection (decreasing fuel spray drop size) resulted in a reduction of NOx and CO (Figure 2) and eliminated impingement of fuel on the hardware. An air to liquid ratio (ALR) of 0.85 was found to produce the lowest emissions (Figure 2). Overall, the NOx levels with B99 were still slightly higher than those for DF2.

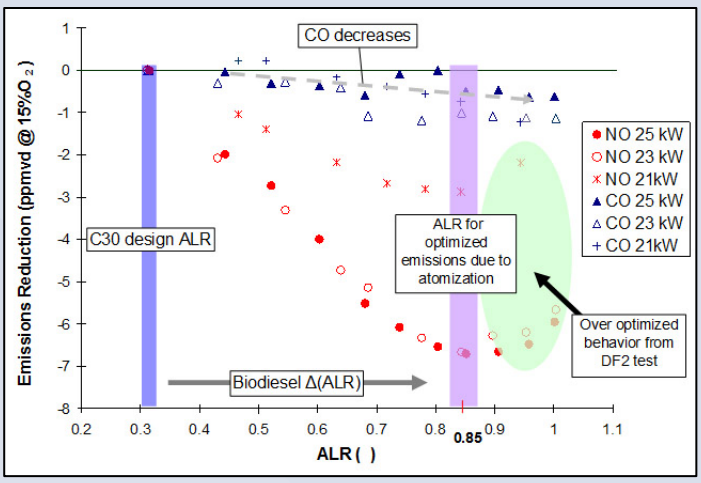

Figure 2: Emissions reduction due to increasing atomizer air flow

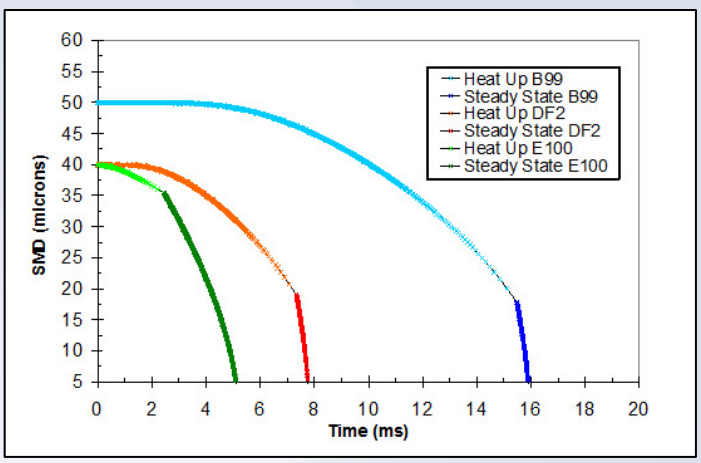

Figure 3: Single droplet evaporation model at engine conditions

Based on the results of modeling the droplet evaporation of these fuels, soy biodiesel, in comparison to petroleum diesel #2, has a significant hurdle to overcome with its larger evaporation time due primarily to its comparatively larger heat up period (Figure 3). The concept of blending small quantities of ethanol into B99 can improve fuel properties (e.g. improving volatility) to more closely simulate an engine's designated fuel, improving system performance, increasing combustion efficiency and decreasing pollutant emissions.

PAPERS & PUBLICATIONS

EVALUATION OF PLAIN-JET AIRBLAST ATOMIZATION AND EVAPORATION OF ALTERNATIVE FUELS IN A SMALL GAS TURBINE ENGINE APPLICATION (2010). Accepted for publication in J. of Atomization and Sprays (C.D. Bolszo and V.G. McDonell)

EMISSIONS OPTIMIZATION OF A BIODIESEL FIRED GAS TURBINE (2008). 32nd Proceeding of the Combustion Institute, Montreal, CA, August 3-8 (C.D. Bolszo and V.G. McDonell).

IMPACT OF BIODIESEL ON FUEL PREPARATION AND EMISSIONS FOR A LIQUID FIRED GAS TURBINE ENGINE (2007). ASME Turbo Expo 2007, Montreal Canada, May 15-18 (C.D. Bolszo, V.G. McDonell and G.S. Samuelsen)

BIODIESEL AIRBLAST ATOMIZATION OPTIMIZATION FOR REDUCING POLLUTANT EMISSION IN SMALL SCALE GAS TURBINE ENGINES (2007). ILASS-Americas 2007, Chicago, IL, May 15-18 (C.D. Bolszo and V.G. McDonell).

OPTIMIZATION OF FUEL PREPARATION FOR EMISSIONS REDUCTION FROM A SMALL SCALE TURBINE ENGINE OPERATED ON BIODIESEL (2007). Western States Section of the Combustion Institute, San Diego, CA, March 25-28 (C.D. Bolszo and V.G. McDonell).

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