Combustion Performance of Biodiesel and Diesel-Vegetable Oil Blends in a Simulated Gas Turbine Burner

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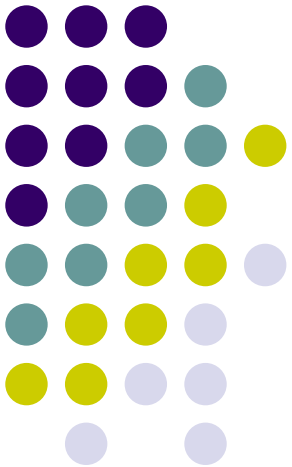

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Introduction

- Investigated combustion performance and emissions of various biofuels
  - NO_x and CO
- Gas turbines run continuously
  - Octane number not a constraint

Fuel	Description
Diesel	Commercial Grade No. 2
Biodiesel No. 1 (BD-1)	Methyl soyate made from soybean oil
Biodiesel No. 2 (BD-2)	Methyl soyate made from chicken fat
Vegetable oil (VO)	100% refined soybean oil
90–10 blend	90% diesel–10% VO
80–20 blend	80% diesel–20% VO
70–30 blend	70% diesel–30% VO

Measurement of Fuel Properties

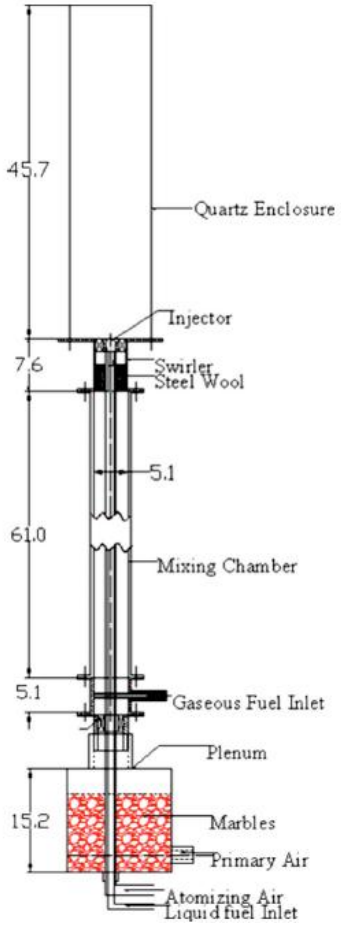
- GC-MS
  - Determine mass % of species present
- TGA
  - Determine thermal stability and volatility
- Density, viscosity, surface tension

Table 3 Physical properties of fuels

Property	Fuel			
	Diesel	BD-1	BD-2	VO
Mol. weight (kg/kmol)	142.2	291.45	289.06	–
Density at 25 °C (kg/m^3)	834.0 ± 9.2	880.0 ± 8.3	868.0 ± 8.8	925.0 ± 8.6
Viscosity at 25 °C (mm^2/s)	3.88 ± 0.016	5.61 ± 0.016	6.14 ± 0.016	53.74 ± 0.220
Surface tension at 25 °C (mN/m)	28.2 ± 0.6	31.1 ± 0.6	30.7 ± 0.6	30.1 ± 0.6
LHV (kJ/kg)	44,601.7	38,002.3	37,659.7	37,000 [4]
LHV (MJ/m^3)	37,198 [12]	33,442	32,689	34,225 [4]

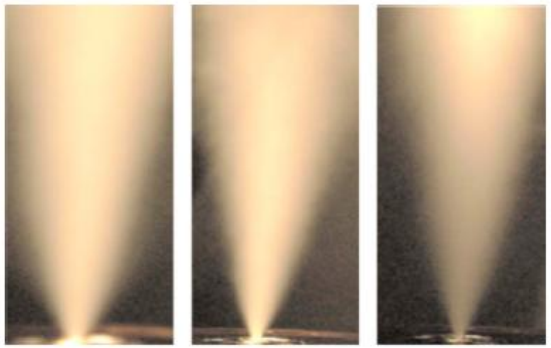
Experimental Setup

- Air pumped with compressor, atomizing air and primary air
- Moves through marbles to eliminate swirling
- Mixed with fuel
- Injected into enclosure and ignited



Spray Angle and Droplet Size

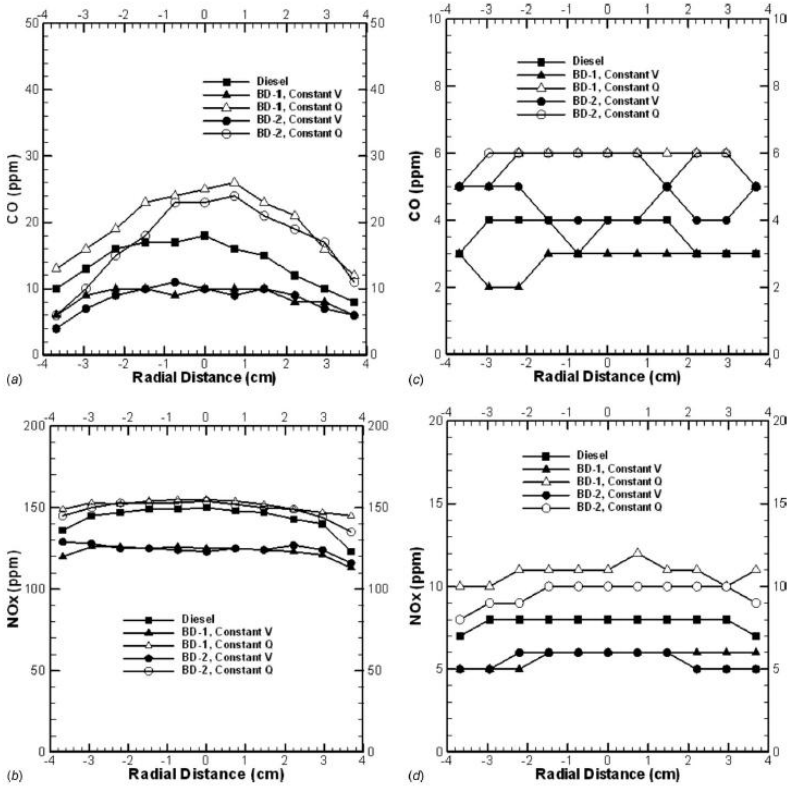
- Effect of Atomizing Airflow (AA) rate
- Sauter mean diameter for droplet size



$$\frac{SMD}{d_o} = 0.48\left(\frac{\sigma}{\rho_A U_R^2 d_o}\right)^{0.4}\left(1+\frac{1}{ALR}\right)^{0.4} + 0.15\left(\frac{\mu_L^2}{\sigma\rho_L d_o}\right)^{0.5}\left(1+\frac{1}{ALR}\right)$$

Results

- Constant heat input (Q) more appropriate model.
- Biodiesel emissions exceed those for standard diesel
- Increasing AA decreases overall emissions, but same trend continues.



Conclusions

- Fuel atomization and flow have a greater effect than fuel chemistry
- Fuel injector can be optimized to reduce emissions
- Increasing the AA rate by 67% decreases CO by a factor of 5
- Increasing the AA rate by 67% decreases NO_x by a factor of 10