

Combustion Sciences for Advanced Propulsion Systems



S&T Campaign: Sciences for Maneuver Energy and Propulsion

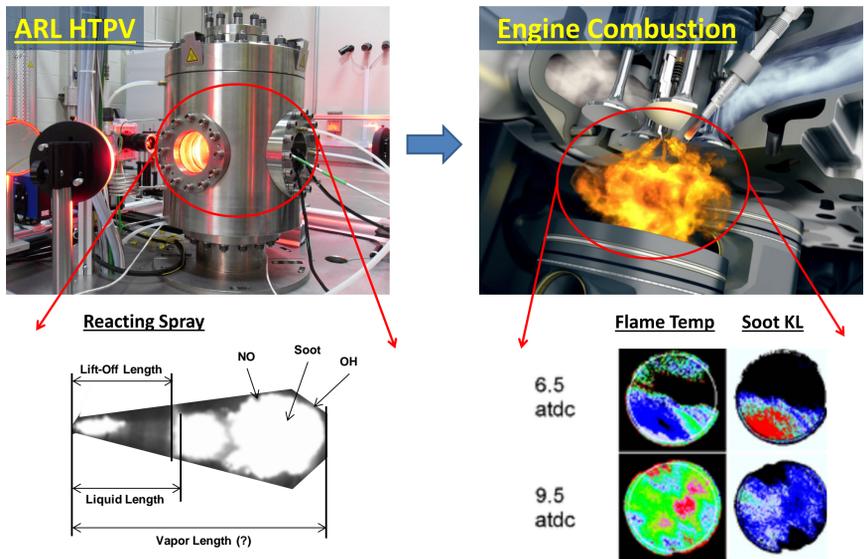
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Research Objective

- Apply discoveries in spray & combustion science to innovate and enable small engine performance and fuel efficiency

ARL Facilities and Capabilities Available to Support Collaborative Research

- Altitude chamber simulating from sea level to 25,000 ft and -40 to 130°F temperatures with two AC dynamometers to handle 1 to 250 hp engines and speeds up to 30,000 rpm using an inline torque meter
- One dual-ended AC dynamometer system (302 hp, 535 Nm, 11,000 rpm max) and two inline torque meters
- Two fuel benches for fuel conditioning and fuel consumption measurements
- Two air-to-liquid charge air cooler to substitute intercoolers
- Two cooling column to substitute coolant radiators
- Two advanced master data acquisition and control system with full control of fuel injectors and actuators, and real-time combustion analysis and monitoring
- One Altech emissions bench, one AVL Opacimeter, and one combustion noise meter



Challenges

- Fuel physical and chemical properties are difficult to control independently (*i.e.*, interrelated properties).
- Current state-of-the-art optical diagnostic methods are insufficient to measure detailed spray structures in dense regions, especially under high temperature and pressure conditions.
- Small engines need shorter liquid and vapor penetration lengths which requires micro nozzles (30-50 μm). Current state-of-the-art nozzle drilling technologies are limited to $\sim 70\mu\text{m}$ without compromising nozzle quality.



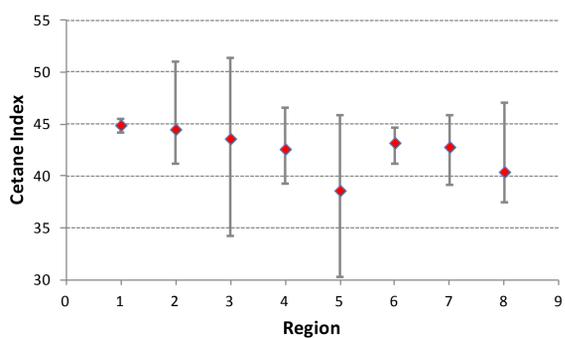
Small Engine Combustion Research Lab



Small Engine Altitude Research Lab

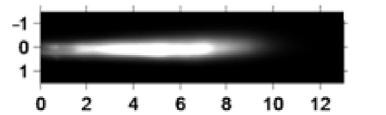
Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- Advanced optical diagnostics expertise applied in combustion system such as PLIF, LII, spectrograph, thermometry, 2-color pyrometry, and X-ray
- High-speed laser diagnostics system
- Detailed fuel chemistry analysis facility
- Single fuel droplet spray and combustion measurement facility
- Advanced 1-D and 3-D CFD analysis capabilities
- Advanced nozzle drilling techniques and facilities
- Advanced 3-D CT scanning expertise and facilities
- Expertise in advanced combustion control algorithm development



Cetane Index (PQMS 2012): Large Cetane Index Variations

GCMS Analysis: dramatic differences in chemistry



Mie scattering: Liquid Fuel Penetration for 47 μm Nozzle

