Technical Highlights – August 2013

Pacific Northwest National Laboratory (PNNL) Exhaust Particle Sampling Campaign at the Oak Ridge National Laboratory (ORNL)- Fuels, Engines, and Emissions Research Center (FEERC)

Two researchers from PNNL, Drs. Alla Zelenyuk-Imre and Jackie Wilson, brought the Single Particle Laser Ablation Time-of-Flight Mass Spectrometer (SPLAT) to ORNL-FEERC in August for a two-week sampling campaign. SPLAT is able to physically and chemically characterize individual particles, thus giving a very complete picture of the particle emissions from an engine. The combination of SPLAT and the advanced engine and fuel technologies at FEERC produced an unprecedented examination of exhaust emissions from lean gasoline direct injection (GDI), partially premixed charge (PPC) gasoline compression ignition, and reactivity-controlled compression ignition (RCCI) under a variety of light-duty operating conditions. The data from this study is expected to help in the understanding of the nature and source of particulate matter (PM) emissions from these technologies.

Cooperation with Marquette Yields Insights into Bio-oil From Municipal Solid Waste

This month, the reach of ORNLs corrosion and chemical speciation capabilities was expanded to include bio-oil from a source rich in nitrogenous compounds, municipal solid waste. In an informal exchange of samples and information, the corrosion and analysis team at ORNL is investigating non-conventional constituents of these municipal waste bio-oils with Marquette University's Onsite Director of the National Science Foundation Industry/University Cooperative Research Center on Water Equipment and Policy. Future work will include facilitating more rapid decision-making surrounding the utility and upgrading requirements of these bio-oil liquids for Marquette.

FEERC Project Awarded to Establish Dynamic Neutron Imaging Capability for Fuel Injectors

Through an internal (ORNL) funding mechanism, a team of researchers for FEERC were awarded a two-year project to establish an advanced neutron imaging capability. The project entitled, "Dynamic Neutron Imaging of Intra-nozzle Fluid Dynamics of Fuel Injectors," proposes to utilize high resolution neutron imaging to obtain intra-nozzle fluid dynamics of a fuel injector, which will guide and validate data-intensive models of both internal flow and spray patterns. The external spray dynamics have been, and continue to be, extensively studied, but these approaches do not easily allow flow visualization inside the dense metallic end-use injectors. Model validation needs a better visualization of fluid dynamics within the injector, particularly as it relates to cavitation and two-phase flow. The unique capability of neutrons to penetrate the metal injector and visualize hydrogen-rich fuel flow enables the connection of the internal and external flows to describe the physics of the spray. In particular, the improvements of both the spatial resolution and neutron flux will aid in the dynamic reconstruction of the fuel injection event. The project aims to develop a capability allowing the visualization of a 1 ms injection event with 20 µs temporal resolution. This will accelerate model development leading to improved injector design and vehicle efficiency.

Full-Size High-Temperature, High-Load (HTHL) Engine Dynamometer Tests Demonstrate Superior Wear Protection for an ORNL-Developed Ionic Liquid (IL) as a Novel Engine Oil Additive

An ORNL-General Motors (GM)-Lubrizol team recently developed the first (ever) prototype engine oil using a novel, ORNL IL as an anti-wear additive. In August, this prototype oil successfully passed the 100-hr HTHL full-size engine dynamometer test at the GM Tech Center. While this IL-additized oil has a very low viscosity (much lower than the newest Society of Automotive Engineers (SAE) 0W-16), it demonstrated an engine wear performance comparable to the high-end Mobil 1 5W-30 engine oil (more viscous). This result demonstrates strong evidence of superior anti-wear functionality for the ionic

additive. The ultra-low viscosity of this IL-additized engine oil is expected to translate to an improved fuel economy, which is currently being validated using the Sequence VID engine dynamometer test at InterTek (to be updated in late September).

ORNL Neutron Imaging Research Highlighted in *Green Car Congress* Article
In an article published online August 21, 2013, *Green Car Congress* highlighted recent neutron imaging research being conducted at ORNL. The article entitled, "Big Science Tools for Clean Transportation: Neutron Scattering at ORNL," focused on transportation research on batteries, fuel injectors, particulate filters, and turbines made with advanced manufacturing techniques. (http://www.greencarcongress.com/2013/08/20130821-neutrons.html)

In-Cylinder Pressure Measurements Achieved for a Miniature Engine Coupled to a Motoring Dynamometer
ORNL recently demonstrated the ability to measure the in-cylinder pressure rise in a 4-cc 2-stroke single cylinder engine. Combustion analysis of small volume engines is extremely limited and only a few attempts have been tried for engines less than 5-cc in displacement. The ability to determine the indicated mean effective pressure and heat release rate are expected to advance the efficiency of small-volume engines to enable more efficient means of portable power generation and Unmanned Aerial System propulsion.

ORNL and Robert Bosch Complete Contracting for Recirculated Exhaust Gas Intake Sensor (REGIS) Funding Opportunity Announcement (FOA) Project
Robert Bosch and ORNL have established a contract that will allow FEERC researchers to begin working on the REGIS project. REGIS is a project to develop a sensor that will allow improved control of exhaust gas recirculation (EGR) in gasoline engines. Improving EGR control will help improve both engine efficiency and emissions performance. The project is a result of a collaborative proposal between Robert Bosch, ORNL, and Clemson University to a Department of Energy (DOE)-issued FOA. FEERC researchers anticipate beginning the technical work for the project in September.

High-Level or Noteworthy Visits

FEERC Hosts Chevron Fuels and Advanced Combustion Research and Development (R&D) Manager
FEERC hosted Bill Cannella and Amir Maria from Chevron Energy Technology Company for a tour of the FEERC engine research facilities and to see first-hand the low-temperature combustion research being carried out at ORNL. The Chevron visitors spent the day observing engine experiments being performed with gasoline compression ignition.

Fuel Economy Simulations for RCCI Combustion Research Presented to Vehicle Systems Simulation Tech-Team
FEERC researcher, Scott Curran, presented findings from a recent fuel economy simulation study estimating the fuel economy potential of RCCI on a light-duty vehicle to the Vehicle Systems Simulation Tech-Team (VSATT). The United States Driving Research and Innovation for Vehicle Efficiency (USDRIVE) VSATT goal is to evaluate the performance and interactions of automotive powertrain components and subsystems, in a vehicle systems context, in order to provide direction for the various USDRIVE technical teams to focus research on areas that maximize the potential for fuel efficiency improvements and emissions reduction.

Invited Talks and Presentations

FEERC Staff Member Invited to Speak at Biomass 2013

Brian West was invited to participate in a Panel Discussion at the Bioenergy Technology Office's annual Biomass 2013 Conference in Washington, D.C., August 1. Brian gave the opening talk in the panel session on "End Use and Fuel Certification" with a presentation on "Making *Better* Use of Ethanol as a Transportation Fuel With 'Renewable Super Premium.'" The presentation explained how today's use of ethanol in E10 and in conventional flex fuel vehicles only allows a gallon of ethanol to displace 2/3rd of a gallon gasoline due to the lower energy density. However, high compression, boosted, downspeeded direct-injection (DI) engines fueled with a high-octane mid-level ethanol blend can enable a gallon of ethanol to displace a gallon of gasoline. Realizing this vision poses a number of challenges, which Brian itemized in his closing statements. Other panelists included Robert McCormick (National Renewable Energy Laboratory), William Woebkenberg (Mercedes), Paul Machiele (Environmental Protection Agency), and John Eichberger (National Association for Convenience Stores).

ORNL Delivers Three Presentations at the Advanced Engine Combustion (AEC) Program Review Meeting

Three ORNL researchers delivered presentations at the bi-annual AEC program review meeting held at the U.S. Council for Automotive Research (USCAR) in Southfield, Michigan: Scott Curran, Derek Splitter, and Jim Szybist. Each delivered a presentation showing recent progress on 3 different high efficiency combustion concepts to an audience of approximately 80 representatives from DOE, industry, academia, and other national labs. All of the presentations were well-received and generated a significant amount of interest and discussion.

FEERC Researcher Leads Session, Speaks at 3rd Annual ORNL Southeast Sustainability Summit

FEERC researcher Scott Curran organized a session entitled "Sustainable Transportation" for the 3rd Annual Southeast Sustainability Summit held August 21–22 in Downtown Knoxville, Tennessee. Regional partners from city government, private industry, and academia gathered for two days of presentations and panel discussions on various aspects of sustainable operations. The Sustainable Transportation panel session featured Scott Curran discussing transportation research at ORNL and how it impacts the public, Kristy Keel-Blackmon from the local DOE Clean Cities discussing regional activities, and Elliott Barnett discussing Natural Gas vehicles and regional incentives.

FEERC Researcher Attends US-China Clean Energy Research Center (CERC) Meeting in Beijing, China

FEERC research Robert Wagner attended the annual US-China CERC Clean Vehicles Consortium meeting in Beijing, China in August 2013. The US team is led by the University of Michigan. ORNL has a significant role in the areas of bio-renewable fuels, combustion, and energy storage. David Wood from ORNL also attended the meeting.