

Technical Highlights – June 2013

Fuels, Engines, and Emissions Research Center (FEERC) Researchers Complete Analysis of the R Factor for Fuel Economy Calculations

Scott Sluder and Brian West recently completed an analysis of the Intermediate Ethanol Blends Catalyst Durability test data to characterize the R factor for modern vehicles. The Environmental Protection Agency (EPA) introduced the R factor into fuel economy results from the Federal Test Procedure (FTP) during the late 1980s in order to deal with fuel formulation variability that was impacting Corporate Average Fuel Economy (CAFÉ) compliance for the automobile manufacturers. The R factor describes how well an engine responds to a change in the volumetric heating value of a fuel to produce more or less fuel economy in a vehicle. In the 1980s the R factor was found to be 0.6; a low value that resulted from the predominance of carburetors for metering fuel into the intake charge. The increasing state of refinement of vehicle fueling has increased the value of R to close to unity; FEERC researchers measured it at 0.94 ± 0.04 for the FTP cycle using data from the Intermediate Ethanol Blends program. The value of R has recently come under increased scrutiny as it has a significant impact to the original equipment manufacturers (OEMs) if ethanol is introduced into the certification fuel, which has been proposed under the Tier 3 emissions rule. FEERC staff worked to release the information rapidly to EPA and industry stakeholders through an Oak Ridge National Laboratory (ORNL) Technical Memorandum (ORNL/TM-2013/198), which is receiving a great deal of attention at EPA and within the industry as the Tier 3 rule is finalized.

Blowback of Exhaust Residuals into Intake Runner Measured on Crank Angle Resolved Basis using Laser Diagnostic Technique

Backflow of exhaust residuals into the intake runner was measured on a crank-angle resolved basis using the exhaust gas recirculation (EGR) Probe developed in the Department of Energy (DOE)-sponsored ORNL-Cummins Combustion Cooperative Research and Development Agreement (CRADA) and SuperTruck projects. The EGR Probe is a minimally invasive spectroscopic-based probe which provides fast measurement of CO_2 , the main combustion product. In this proof-of-principle experimental campaign, the probe was installed in the intake manifold of the ORNL single-cylinder engine, which is equipped with hydraulic valve actuation (HVA). The HVA valvetrain allows direct control of intake and exhaust valve opening and closing, and specifically variable valve phasing over a wider range than typical of a production-intent engine. The proof-of-principle experiments used various overlap valve timing strategies to create varying levels of residual backflow. Preliminary results show the ability to resolve progressively increasing backflow with a response time on the order of 1ms. Backflow measurements are relevant to quantifying cylinder charge and its fluctuations; critical parameters to enabling advance efficiency combustion methodologies. The demonstration measurements indicate the EGR Probe may be a useful tool in understanding air handling processes and cycle-to-cycle variability in advanced combustion operation modes. This work was performed by ORNL FEERC Postdoctorial Research Associates Dr. Jon Yoo and Dr. Derek Splitter and Research Staff Dr. Jim Szybist and Dr. Bill Partridge.

ORNL-General Motors (GM) Team Develops First (ever) Formulated Automotive Engine Oil Using an ORNL Oil-Miscible Ionic Liquid as Anti-Wear Additive and Demonstrated Superior Lubricating Performance in Bench Testing

An ORNL team led by Dr. Jun Qu has recently worked with GM and a leading additive company to develop the first version of fully-formulated automotive engine oil using an oil-miscible ionic liquid developed at ORNL. GM's tribological bench tests on this new ionic liquid-additized engine oil have

demonstrated substantially reduced friction AND wear compared to the high-end synthetic Mobil 1 5W30 engine oil. GM has scheduled full-size engine dyno-tests to more thoroughly evaluate the oil.

High Level DOE Milestone for Mapping Reactivity Controlled Compression Ignition (RCCI) Met

A team of FEERC researchers led by Scott Curran successfully met a high level DOE milestone developing an engine map on a multi-cylinder engine which is suitable for light-duty drive cycle simulations. The map was developed to maximize efficiency with lowest possible emissions with production viable hardware. This map will be used for a subsequent milestone to model RCCI fuel economy with vehicle systems simulation software to estimate drive-cycle fuel economy and emissions from the advanced combustion mode.

Similar Corrosion Behavior Observed Mild Steel Coupons Exposed to ultra-low sulfur diesel (ULSD) or Low-Sulfur Diesel (LSD)

ORNL researchers Mike Kass and Sam Lewis are evaluating the corrosion on mild steel coupons exposed to ULSD or LSD. Since ULSD (which has a sulfur concentration below 15ppm) was introduced to replace LSD (less than 500ppm sulfur), there have been incidental reports of extensive corrosion occurring to some steel components located inside the fuel tanks. One theory is that the higher fuel sulfur content of LSD acted as a biocide to inhibit microbe growth leading to the formation of acetic acid. To test this theory, mild steel coupons were placed inside containers filled with LSD or ULSD. Each container was spiked with water and bacteria. After two weeks the samples were removed. Significant (and equivalent) corrosion was observed for samples exposed to either LSD or ULSD spiked with water and bacteria. Coupons exposed to neat fuel or fuel spiked with water only (no introduced bacteria) did not show significant corrosion.

Vehicle Research Laboratory Study of Air Conditioner Use on Fuel Economy Featured in the Society of Automotive Engineers (SAEs) Automotive Engineering International Magazine

One of the recent Vehicle Research Laboratory papers published and presented at the 2013 SAE World Congress was featured in an SAE magazine. The article is based on a study [1] which explores fuel economy penalties for air conditioner use and driving with windows down – and can be found on pages 14–19 of the June 18th edition of *Automotive Engineering International Magazine*.

1. S. P. Huff, B. H. West, and J. F. Thomas, "Effects of Air Conditioner Use on Real-World Fuel Economy," SAE Paper number 2013-01-0551, 2013 SAE World Congress, Detroit, Michigan, April 16–18, 2013.

Magazine article link:

<http://www.nxtbook.com/nxtbooks/sae/13AEID0618/?partner=3531434143334130373542354435363238443635363232334343413035354131&startid=14&lre=1>

Invited Talks and Presentations

FEERC Presents RCCI Emissions Research at Emissions 2013 Conference

FEERC Researcher Scott Curran presented an invited talk at the Emissions 2013 conference held at Eastern Michigan University. Recent findings on hydrocarbon speciation and particulate matter from RCCI combustion were presented. FEERC Director Robert Wagner was also an organizer for the conference.

FEERC Researchers Participate in the Engine Research Center (ERC) 2013 Symposium on Fuel Efficiency and Advanced Combustion

FEERC researcher Stuart Daw was an invited presenter at the ERC Symposium, in June 2013. The bi-annual symposium was organized to discuss Engine Fuel Efficiency and Advanced Combustion and was hosted by the University of Wisconsin–Madison. Dr. Daw presented an overview of the recent work done by several ORNL FEERC researchers on light-duty diesel engines capable of utilizing RCCI. Dr. Daw's presentation highlighted experimental measurements and drive-cycle simulations at ORNL that reveal both the potential benefits and the technical challenges associated with utilizing RCCI to achieve higher fuel economy while remaining within evolving emission constraints. The meeting was attended by FEERC members Scott Curran and Derek Splitter, along with approximately 200 other researchers from other national laboratories, universities, and industry.

Invited Talk by ORNL Researcher at Southwest Research Institute (SwRI) High Efficiency Dilute Gasoline Engine (HEDGE) Consortium Meeting

Jim Szybist delivered an invited talk at the June meeting of the HEDGE Consortium at SwRI. The subject of the talk was non-catalytic in-cylinder fuel reforming in one engine cylinder for the purpose of producing hydrogen to enable dilute SI combustion in the remaining cylinders. ORNL is not a member of the HEDGE consortium, so this invited talk provided an opportunity for DOE-sponsored study to be presented to a large group of relevant researchers from industry. The talk was well-received and spurred a great deal of discussion.

FEERC Researcher Presents Invited Lecture at Future Automobiles Meeting in Greece

Robert Wagner of the Fuels, Engines, and Emissions Research Center presented a plenary lecture at the invitation-only "12th International Conference on Present and Future Engines for Automobiles" in Delphi, Greece. The topic of his talk was "Pushing the Stability Limits of Clean High Efficiency Engines." This meeting occurs every 2–3 years with attendance limited to approximately 70–100 people. Session topics spanned international perspectives, state of the art powertrain technologies, fuel economy, engine combustion and fuels, and engine emissions and aftertreatment.

Awards

FEERC Researcher Receives Early Career Award from American Society of Mechanical Engineers (ASME)

FEERC Researcher Scott Curran received the second place 2013 ASME Old Guard Early Career Award for "dedication to the ASME goal of helping the global engineering community develop solution to benefit lives and livelihoods through advances in energy efficiency and alternative fuel research, as evidenced by involvement with ASME conferences; science, technology, engineering and mathematics recruiting; and public outreach and education". The significant award includes a lifetime prepaid membership to ASME.

Outreach

FEERC Hosts Two Participants of the Siemens Teachers as Researchers (STARs) Program

In June FEERC hosted two STARs Fellowship participants. One of the teachers was Mariann Brown, who after receiving a BS in bioengineering and working for NASA, went back to school for a Masters in Education and now teaches 5th–8th grade science and algebra at a small Lutheran K–8 school in Georgetown, Texas. The other teacher was Dan Boren, who has a B.S.E. (Biology), an M.A.T. in Physics, and a M.S. in Christian Ministry. Dan pastors a church in Roscoe, Texas while continuing his 20 year career of teaching high school science, and he is the teaching sponsor for the Roscoe Collegiate High

School Plowbots FIRST Robotics team. Both fellows spoke highly of their experience and were extremely grateful for this opportunity. They were able to participate in a fuel economy study that is in the beginning stages in the FEERC Vehicle Research Laboratory. This allowed them the chance to learn all aspects of vehicle research such as laboratory safety, vehicle installation and setup, and instrument calibration, as well as data acquisition, collection, and reduction. Additionally, our fellows were able to experience the challenges of driving a vehicle on a chassis dynamometer while attempting to follow a vehicle certification drive cycle. In fact, the initial data for the study has been collected with our fellows doing all the driving. Major “take aways” for our fellows includes quotes such as, “Now I can tell my students that people really use the quadratic equation in their job,” by Mariann. Also, Dan said, “These concepts will help our teachers fulfill the Texas Essential Knowledge and Skills (TEKS) requirement.” A short video that highlights the experiences of our STARs participants has also been posted.