Technical Highlights for February 2012

Chalmers Student Licentiate Conferred Base on Work at the Oak Ridge National Laboratory (ORNL)

Xavier Auvray received his Licentiate of Engineering November 24, 2011 from the Department of Chemical and Biological Engineering at Chalmers University of Technology (Gőteborg, Sweden) based in large part on work he did at ORNL. This work was part of an ongoing collaboration between ORNL staff member Dr. Bill Partridge and Chalmers Professor Dr. Louise Olsson focused on experimental characterization and modeling of automotive selective catalytic reduction (SCR) catalysts. Xavier performed experimental SCR research during his visit to ORNL June 14–November 12, 2010, which was sponsored by the Swedish Foundation for Strategic Research. That work was in support of ORNL's Department of Energy (DOE)-funded cross-cut lean exhaust emissions reduction simulations (CLEERS) project, but also directly contributed to their separate DOE-funded Cooperative Research and Development Agreement (CRADA) with Cummins, Inc. In addition to Dr. Partridge, other ORNL staff participating in Xavier's visit included Jae-Soon Choi, Josh Pihl, Todd Toops, Jim Parks, and Stuart Daw. This work was the focus of a Keynote Lecture at the 2011 EuropaCat Conference in Glasgow, Scotland.

Cummins and ORNL CRADA Team Works to Assess Exhaust Gas Recirculation (EGR) System

ORNL Fuels, Engines, and Emissions Research Center (FEERC) staff member Bill Partridge and Oak Ridge Associated Universities (ORAU) Post-Doctorial Research Associate Jon Yoo did on-site work at the Cummins Technical Center to make certain EGR-system assessments on a development engine. This work was performed under the Combustion section of the Cummins-ORNL\FEERC CRADA. The Cummins team members were led by Bill Partridge's Co-PI and Cummins staff member Sam Geckler. This campaign provided successful field demonstration of the CRADA-developed EGR probe, which provides single-port measurement access for more ready and flexible applications to further developed and packaged engine systems. The work focused on spatiotemporal EGR uniformity and provided new insights relevant to product development. Based on this work modifications are planned for both the instrument and EGR system, and the team plans for a follow-up measurement campaign this summer.

FEERC Staff Test Summary: ORNL-UOP Green Diesel experiments

Date of Experiments: 2/20–24/12; Prepared by: Michael Bunce and Bruce Bunting.

Blends of green diesel obtained from UOP were prepared by ORNL in the following ratios: B0, B10, B25, B50, B75, and B100. Samples were sent for analysis, which revealed green diesel (B100) to have a derived cetane number of approximately 82.6, significantly higher than that of Ultra Low Sulfur Diesel (ULSD). The blends were run on a single cylinder diesel engine in a load sweep. The higher energy content of green diesel results in slightly higher indicated mean effective pressure (IMEP) and lower indicated specific fuel consumption (ISFC) with increasing bio-content. While little difference, if any, can be detected in soot and CO levels amongst the blends, increasing bio-content corresponds to significant reductions in both NO_X (~29% reduction with B100 at high load) and HC (~75% reduction with B100 at low load) emissions. Preliminary examination of the heat release data indicates that the earlier combustion of green diesel due to higher cetane number results in less pre-mixed combustion. ULSD has a longer ignition delay resulting in a heat release peak much larger than that of B100 when pre-mixed combustion occurs. This disparity in heat release peaks may also result in a temperature disparity inside the cylinder, with the higher cylinder temperatures of ULSD combustion leading to higher NO_X levels. Further research into the root cause of the NO_X and HC reductions with green diesel is ongoing.

New Boosting and External EGR Capabilities Demonstrated on ORNL Single Cylinder Engine with Hydraulic Valve Actuation (HVA)

New boosting and external EGR capabilities are being utilized on the ORNL single cylinder engine with HVA in a study to determine the impact of low-grade hydrocarbon (HC) blending streams on high ethanol-content fuels. The upgrades to the air-handling system were started in the first quarter of FY2012 and completed at the beginning of the second quarter, making this the first time these capabilities have been used in an experimental campaign on this engine platform. The ability to implement high levels of boost and EGR are consistent with the trends of engine down-sizing and dilute combustion, so the upgrade was essential to stay on the leading edge of automotive technology. The air-handling system upgrades combined with both direct injection and port-fuel injection fuel systems, flexible hydraulic valve actuation, and the capability to run the ORNL six-stroke engine cycle makes this a uniquely capable research platform within the DOE system.

ORNL-FEERC Hosts University of South Carolina Graduate Student in Initial Collaboration on Lean Gasoline Investigation

As part of an ongoing collaboration between ORNL and the University of South Carolina, Chris Digiulio (Ph.D. candidate, advised by Professor Michael Amiridis) was hosted by Todd J. Toops and James E. Parks to conduct research on the effects of lean/rich timing on nitrogen oxide (NO_X) reduction and on-board ammonia (NH_3) formation for applications into lean gasoline vehicles. Efforts are being guided through discussions with General Motors, Umicore, and the University of Wisconsin to enable low cost emissions control strategies that would enable the introduction of fuel efficient lean gasoline vehicles.

ORNL–Institute of Chemical Technology Prague (ICTP) Prague Team Receives Funding for Catalyst Modeling

A team led by Professor Miloš Marek and Dr. Petr Kočí of ICTP, and Drs. Bill Partridge and Jae-Soon Choi of ORNL have received funding for catalytic kinetic modeling research. The project is titled "Analysis, Modeling and Control of Spatiotemporal Concentration Patterns in Nitrogen Oxide Reduction ($deNO_X$) Catalysts for Automotive Exhaust Gas Aftertreatment," and will receive 2012–2014 funding from the Czech Republic via the KONTAKT-II program; details of the 2012 funded programs is available at http://www.amvis.cz/files/VES_2012_approved.pdf. The project will fund ICTP staff participation and on-site work at ORNL and is supportive of ORNL's DOE-funded CLEERS and CRADA programs. The general model for this collaborative project is that ORNL performs experimental work under their DOE projects, ICTP incorporates the resulting insights into their model via the KONTAKT II project, and the team works together to interpret the results and plan the next steps. The overarching kinetic results will be posted to the CLEERS website.

ORNL Publishes Final Report on Intermediate Ethanol Blends

ORNL published a final report on the Intermediate Blends Catalyst Durability Study this month. The two-year program involved driving 82 vehicles over 6 million miles with periodic emissions tests to evaluate the effects of ethanol blends (E10, E15, and E20) on emissions control system durability. The program was closely monitored by stakeholders (DOE, EPA, and industry) and garnered the attention of the Congress, the Energy Secretary and the EPA Administrator.

Statistical analysis of the data showed that (as expected) aging vehicles increased emissions. However aging with ethanol blends showed no differential effect over aging with ethanol-free gasoline. Immediate effects of ethanol were consistent with prior studies; addition of ethanol to certification gasoline decreased CO, NMHC, and fuel economy, while increasing NOx, ethanol, and aldehyde emissions. The study results were the basis of the recent EPA rulings on the Growth Energy E15 waiver. EPA described the study as unprecedented in size and scope when they cited the E0 and E15 data in granting partial approval of the Growth Energy waiver, allowing E15 use in 2001 and newer light-duty vehicles. The analysis in the published report additionally addresses the emissions impacts of E20; intermediate blends (E15 and E20) were not found to contribute to more rapid emissions control system degradation (as compared to ethanol-free gasoline). Use of intermediate ethanol blends would allow ethanol to make a more substantial contribution to EISA compliance through the non-FFV legacy fleet.

FEERC Staff Host Butamax Advanced Biofuels and Underwriters Laboratories Representatives

Mike Kass and Tim Theiss hosted a visit by Butamax Advanced Biofuels and Underwriters Laboratories to discuss an upcoming project to assess isobutanol compatibility with fueling infrastructure materials. Test materials have been procured and are currently being prepped for exposure to test fuels containing 16% and 24% isobutanol. This effort is expected to commence in mid-March.

FEERC Presents Combustion Research at DOE Advanced Engine Combustion (AEC) Working Group Meeting

Several FEERC staff attended and presented at the DOE's AEC working group meeting at Sandia National Laboratories in Livermore, California on February 14, 2012. This bi-annual meeting provides a forum for DOE laboratories, industry, and universities to present and discuss research funded by the DOE Vehicle Technologies Program. Presenters from ORNL included Jim Szybist presenting on "Preliminary Experimental Measurements of In-Cylinder Fuel Reforming" and Scott Curran presenting on "Range-Extension and Multi-Cylinder Performance of Reactivity Controlled Compression Ignition (RCCI) Combustion." Robert Wagner also attended the meeting.

FEERC Staff Presents a Colloquium at the University of Tennessee-Knoxville (UTK), Department of Mathematics

Andreas Malikopoulos delivered a talk entitled " Equilibrium Control Policies for Marko chains Subject to Total Variation Distance Uncertainty," presenting new theoretical contributions in stochastic optimization and control on February 24, 2012. This work funded by the Laboratory Directed Research and Development (LDRD)

program (Weinberg fellowship) at ORNL can be utilized towards making complex engineering systems, e.g., internal combustion engines, hybrid electric vehicles (HEVs), plug-in electric vehicle (PEVs), etc, into autonomous intelligent systems that can learn how to improve their performance over time while interacting with their environment.

FEERC Staff Speaks at UTK

Maggie Connatser was the invited alumna speaker at UTK Department of Chemistry's Research Open House (graduate recruiting) on February 25, 2012.

ORNL Emissions Control Research to be Presented at Ninth International Congress on Catalysis and Automotive Pollution Control (CAPoC9)

Five ORNL abstracts were accepted for presentation at the Ninth International Congress on Catalysis and Automotive Pollution Control (CAPoC9). This triennial conference will be held in Belgium and brings together emissions control researchers from across the globe to discuss new directions in low-cost catalysis for the abatement of automotive emissions. ORNL research topics to be presented include studies on the compatibility of biodiesel with SCR catalysis, soot oxidation kinetics in particulate filters, lean gasoline vehicle lean NO_X trap (LNT) behavior, NH_3 storage in SCR catalysts, and distributed temperature measurements in emissions control systems. Scheduled presenters will be Todd J. Toops and William P. Partridge.

FEERC Staff Judges Physical Science Competition

Maggie Connatser was an invited judge of the 3rd/4th grade Physical Science Competition at the Tate's School annual science fair on February 23, 2012.

FEERC Staff Supports 2012 F.I.R.S.T. Robotics High School Team Competition

ORNL hosted approximately a dozen teams from local high schools at the newly completed NTRC-2 Building (housing the Manufacturing Demo Facility, MDF) for the construction and testing of team robots for the 2012 F.I.R.S.T. Robotics Competition. Students interacted with ORNL engineers and technicians during the course of the robot constructions. The students had six weeks to work on their robots. At the end of six weeks, the robots were placed in individual bags and sealed with security tags. The competition for the FIRST Smokey Mountain Regional will be held at the Knoxville Convention Center on March 1st through 3rd with opening ceremonies on March 1st for this competition season. FEERC participants included Jeff Chambers, Jimmie Wade, and Steve Whitted. Other ORNL staff who also had major contributions included Jarrad Stump and John Czachowski among others.