TECHNICAL HIGHLIGHTS for MAY 2014

Charles Finney and Team Received a 2014 ASCR Leadership Computing Challenge (ALCC) Award

A team led by Charles Finney received a 2014 ASCR ALCC Award to study cyclic variability in dilute internal combustion engines. Researchers from the Fuels, Engines, and Emissions Research Center (FEERC), Ford Motor Company, Convergent Science, Inc., and the Oak Ridge National Laboratory's (ORNL's) Computer Science and Mathematics Division have been allocated 17.5M processor hours on Titan over one year starting in July 2014. The team will employ the computational fluid dynamic (CFD) code CONVERGE to study significant factors influencing cyclic variability in a light-duty gasoline-direct injection (GDI) engine operating at stoichiometric fueling with high levels of exhaust gas recirculation (EGR). Results from this study will help guide future modeling and experimental research and development (R&D) to enhance the stability of dilute combustion over a wider range of engine operation.

FEERC/ORNL Team Partners with General Motors (GM) on 2014 ALCC Award

GM in collaboration with ORNL received an ALCC award of 15 M hours towards a project titled "Multi-hole injector optimization for spark-ignited direct-injection gasoline engines." This project utilizes the infrastructure developed and tested by ORNL researchers in collaboration with GM to perform simulations of large parametric sweeps of injector nozzle designs over the last 18 months through support from the EERE Advanced Combustion Engines R&D Program which is managed by Gurpreet Singh for the Vehicle Technologies Office. In this new project, the internal spray calculations from OpenFOAM will be combined with the external spray simulations in CONVERGE for simulating mixing in cylinders to develop an advanced toolset to accelerate engine design and improve vehicle fuel economy. Additionally, this project seeks to explore the use of graphics processing units (GPUs) to improve the scalability and turnaround time of nozzle flow simulations in OpenFOAM. The ORNL team is led by Dr. Sreekanth Pannala of the Computing & Computational Sciences Directorate.

Fuel System Elastomers Studied in 20% Bio-oil Heating Oil Exposure Experiment

ORNL is investigating the compatibility of fueling infrastructure materials (common to home heating oil systems) to fuels containing bio-oil. Elastomer and plastic materials were exposed to test fuels containing No. 2 off-road diesel fuel (also known as home heating oil) and a blend of No. 2 diesel fuel containing 20% bio-oil. Elastomer materials included fluorocarbon, fluorosilicone, acrylonitrile rubbers, styrene butadiene rubber, polyurethane, neoprene, and silicone rubber. Except for fluorosilicone, all of the elastomer specimens swelled over 60%, which is considered high. Fluorocarbons have good compatibility properties with most solvents and fuels, but they are susceptible to ketones. Cursory analysis of the bio-oil did reveal minor quantities of acetone, which would contribute to the high volume expansion. High levels of softening accompanied the volume increase. These results indicate that polymeric infrastructure materials typically used in fueling infrastructure systems may not be compatible to some biofuels and that their use may need to be limited. Further results are pending.

ORNL Team Integrates Fuel Injector Movement with Neutron Detector to Demonstrate Dynamic Imaging Capability

A recently installed micro-channel plate (MCP) detector was integrated with a GDI (gasoline direct-injection) fuel injector at ORNL's High Flux Isotope Reactor (HFIR). In doing so a stroboscopic-based technique was employed to capture internal injector dynamics with a video of the needle lifting and closing during operation; this experiment was done without spraying fluid and with a time resolution of 20 microseconds. The injector action was repeated over 1 million times to capture the time-stamped images with high enough visual statistics to differentiate the movement. Efforts are moving forward

with fluid injection to capture the internal fluid dynamics during operation. In studying the hydrocarbons (HCs) and their increased interaction with neutrons it is expected we will be able to dramatically reduce the overall required time required as 1 million repeats is not expected to be necessary.

FEERC Multi-Cylinder Reactivity-Controlled Compression Ignition (RCCI) Engine Experiments conducted with CFD- Optimized Piston Design

In collaboration with the Wisconsin Engine Research Consultants (WERC), FEERC researchers Adam Dempsey and Scott Curran have completed the first round of experiments evaluating a unique piston design for advanced combustion engines, namely dual-fuel RCCI. The pistons were designed using CFD simulations as part of a joint project funded under the DOE FOA awards between WERC, ORNL, the University of Wisconsin-Madison, and Caterpillar. Using a multi-cylinder light-duty engine, the unique piston design was evaluated at a variety of operating conditions and comparisons will be made to a more conventional piston bowl geometry. The pistons were designed to reduce pressure rise rates by containing the high reactivity diesel fuel in the center of the combustion chamber. In addition, the ring pack design has been modified to minimize HC and carbon monoxide (CO) emissions from premixed strategies like RCCI. The results of the experiments are being provided back to WERC for model validation and will be published in an upcoming paper.

Idaho National Laboratory (INL) Electric Drive and Advanced Battery (EDAB) and Components Testbed Vehicle Calibration and Validation Conducted in FEERC Vehicle Research Laboratory (VRL)

The EDAB vehicle developed under contract for INL was tested at ORNL in the FEERC VRL. This vehicle was configured to emulate the behavior of a Chevy VOLT in order to evaluate how an experimental battery pack would perform in the VOLT. The FEERC role in the testing was to provide support and assistance to Paul Chambon of the Power Electronics and Electric Machinery Research Center (PEEMRC) in calibrating the battery management system and then validating the calibration against data collected by Argonne National Laboratory (ANL) using a production Chevy VOLT. Barney Carlson of INL, and two engineers from Intertek Testing Services visited ORNL to observe the experiments.

University of Wisconsin RCCI Hybrid Vehicle Experiments Conducted at ORNL

One post-doctoral research associate and one graduate student from the University of Wisconsin-Madison brought a student-designed hybrid vehicle equipped with an RCCI/diesel engine to the FEERC chassis dynamometer for evaluation. The chassis dynamometer experiments lead by FEERC researcher Shean Huff focused on evaluating fuel economy and emissions over a number of drive cycles. The proto-type vehicle is one of the first public vehicle-level demonstrations of advanced combustion engine technology. The series hybrid vehicle powertrain uses an RCCI engine running at a single high efficiency power point (one specific engine speed and load) to maintain the state of charge on the high-voltage battery pack over the drive cycle. The vehicle was equipped with a fully flexible microprocessor-based control system from National Instruments allowing the engine load point to be changed to match the drive cycle. An aftertreatment system including oxidation catalyst and a particulate filter were in place to evaluate performance of the aftertreatment system during the course of the drive cycles.

High-Level or Noteworthy Visits

Emission Control Suppliers, CDTi and Alantum, visit ORNL

In separate visits, two emission control suppliers (CDTi and Alantum) visited ORNL to discuss catalyst and substrate technologies for controlling emissions from advanced fuel efficient engines. CDTi is a catalyst company with advanced catalyst formulations for the automotive and diesel engine industries. Alantum

markets a unique metal foam substrate that could potentially offer advantages for fuel efficient control of particulate matter (PM).

FEERC Hosts EcoCAR 2 Student Presentations before Third and Final Year of Competition
FEERC hosted multiple groups of students from the University of Tennessee's (UT's) EcoCAR 2 hybrid vehicle design team for dry-run presentations before the year 3 competition. EcoCAR 2 is a three-year collegiate vehicle design competition sponsored by the Department of Energy and GM and managed by ANL. The UT students presented their technical and outreach presentations to experts in transportation science and sustainable vehicles on areas ranging from hybrid vehicle controls to mechanical integration of sub components to their outreach and education program. UT, along with the 14 other universities, will compete at the Milford Proving Grounds outside of Detroit in June with final presentations the following week in Washington, D.C. More information about the EcoCAR 2 competition can be found at http://www.ecocar2.org/.

Invited Talks and Presentations

GDI PM Research Described to Automotive Emissions Controls Group
John Storey visited the Manufacturers of Emissions Control Association (MECA) semi-annual meeting on May 8 (with Gurpreet and Leo) and gave an invited presentation entitled "GDI PM Characterization: Physical, Chemical, Morphological, and Oxidation Properties." There was discussion during and after the presentation about the scope of GDI PM emissions and potential engine and aftertreatment control solutions.

ORNL Presentations on Advanced Lubricants at the Society of Tribologists and Lubrication (STLE) Annual Meeting Generate Industry interest
Jun Qu gave four technical presentations including an invited talk on "Oil-Miscible Ionic Liquids as Lubricant Additives" in the Panel Discussion: *Ionic Liquids for Lubrication* at the STLE 69th Annual Meeting in Orlando, Florida. All presentations were very well received – numerous attendees approached Jun after each talk for follow-up discussions. Several companies including BASF, Chevron, Southwest Research Institute (SwRI), Moog, and Phillips 66 expressed strong interest in working with ORNL on both lubricant development and surface characterization.

Awards

Scott Curran awarded Ph.D. in Energy Science and Engineering
FEERC staff member Scott Curran was recently awarded a Ph.D. in Energy Science and Engineering and became one of the first two doctoral graduates from the new Bredesen Center for Interdisciplinary Research and Graduate Education at UT. Scott also worked closely with Robert Wagner of FEERC to establish a new Transportation Science thrust area within the center. The Bredesen Center for Interdisciplinary Research and Graduate Education unites extensive and complementary resources at UT and ORNL to advance science, technology, engineering, and mathematics research related to energy. Seeking to create opportunities for exceptional students to engage in interdisciplinary research and education, the Bredesen Center offers doctoral fellowships to candidates pursuing studies in energy science and engineering.

ORNL Team Receives UT-Battelle Significant Event Awards for "Development of Lubricant that Meets DOE Goal of 2% Vehicle Fuel Economy Improvement

Jun Qu, Huimin Luo, Sheng Dai, Todd Toops and Peter Blau (retired) collaborated with GM and Lubrizol and sponsored by the Fuels and Lubricants Program of the DOE Vehicle Technology Office, has recently produced an prototype fully-formulated ultra-low-viscosity engine oil using ORNL's novel ionic liquid as an anti-wear additive, which was the first in the literature. This prototype IL-additized engine oil demonstrated 2% improved fuel economy improvement and engine wear protection similar to Mobil 1 SAE 5W-30 engine oil in standard industrial standard engine dynamometer tests. This result positions ORNL as a national leader in the lubricants research for fuel economy improvement.