Technical Highlights May 2013

The Oak Ridge National Laboratory (ORNL) Successfully Demonstrates an Engine Head Manufactured Using Additive Manufacturing

Mark Noakes and Mike Kass successfully operated a small single-cylinder two-stroke engine equipped with a head manufactured using additive manufacturing technology. Additive manufacturing allowed the researchers to incorporate a sensor port for in-cylinder pressure measurement in the printed head. (In contrast, the stock aluminum head does not have enough material to machine in a sensor port.) The printed titanium head was run at several speed conditions and the fuel consumption was compared to the original aluminum head for two different throttle settings. For an optimal air fuel ratio (AFR), the titanium head matched the performance of the stock aluminum head. However, when the AFR was reduced by 20%, the titanium head improved the fuel efficiency by an average of 10% compared to the aluminum head. This efficiency improvement is attributed reduced wall heat losses associated with the much lower thermal conductivity of titanium (compared to aluminum).

Lean NO_X Control Using Ethanol/Gasoline Blends with Ethanol Contents as Low as 50% Over a Silver/Alumina Catalyst Demonstrated

High efficiency lean gasoline engines and high ethanol content fuel blends (such as E85) are strategies that could significantly reduce United States (U.S.) petroleum consumption, but both face challenges preventing widespread adoption. Lean gasoline vehicles are currently unable to cost effectively meet U.S. NO_X emissions regulations. E85 has not seen widespread use due to ethanol's lower energy density and associated reductions in tank mileage. Researchers at ORNL's Fuels, Engines, and Emissions Research Center (FEERC) are searching for synergies between these strategies by exploiting the unique chemical reactivity of ethanol to facilitate cost effective NO_X control for lean gasoline engines. Our goal is to enable vehicles with emissions-compliant high efficiency lean gasoline engines that consume less petroleum and go further on a tank of fuel when running on high ethanol blends. Prior work at FEERC demonstrated that ethanol is an effective reductant for removing NO_X from lean gasoline and lean diesel exhaust when it is introduced upstream of an industrially formulated silver/alumina catalyst; more recent efforts have focused on synthetic lean gasoline engine exhaust mixtures in a bench reactor. We recently extended our flow reactor investigations to include blends of ethanol and gasoline as the reductant. We found that ethanol blends as low as 50% still achieve NO_X conversion efficiencies in excess of 90%. These results demonstrate that a silver/alumina catalyst could achieve lean NO_X control with realistic ethanol/gasoline blends. Future work will include evaluation of this strategy on a recently installed lean gasoline-direct injection (GDI) engine platform.

Mechanisms of Lubricant Anti-Wear (AW) Tribo-Film Formation on Advanced Hard Coatings Revealed

Lubricant AW additives, such as zinc dithiophosphate (ZDDP), are known to protect ferrous bearing interfaces by forming a 50–150 nm thick, self-healing tribo-film, as a result of tribo-chemical reactions. However, there is lack of understanding of ZDDP's compatibility with advanced hard coatings, such as diamond like carbon (DLC) and borides. ORNL's recent study has discovered that the ZDDP tribo-film on DLC is thin (10–20 nm) and only covers a small portion (20–30%) of the contact area and, in contrast, the tribo-films on boride coatings are 60–80 nm thick with >80% surface coverage. A new tribo-film formation mechanism has been revealed for DLC compared to ferrous alloys: unlike directly chemically reacting with the metal surface in lubricating ferrous alloys, ZDDP reacts with the metallic wear debris from the steel counterface (rubbing against DLC) to form the tribo-film on DLC.

Invited Talks and Presentations

FEERC Researchers Well Represented at Annual Merit Review (AMR)
FEERC staff provided strong representation at the Department of Energy (DOE) AMR with at least 13 first-author podium presentations. Research in Advanced Combustion Engines, Advanced Emissions Control, Fuel and Lubricant Technology, Vehicle Systems, and Advanced Propulsion Materials were presented by FEERC or ORNL staff. FEERC staff were coauthors or collaborators on numerous other presentations and posters from universities, other national laboratories, and industry. In addition, several FEERC and ORNL staff served as reviewers for some of the industry presentations. This level of participation and reference demonstrates the breadth, depth, and impact of FEERC research in addressing the challenges of advanced transportation and the Vehicle Technologies Program.

Awards

FEERC Researchers Receive 2013 DOE Vehicle Technologies Office Research and Development (R&D) Award
FEERC researcher, Scott Curran, received a 2013 DOE Vehicle Technologies Office R&D Award in recognition for leadership in transitioning reactivity controlled compression ignition (RCCI) combustion from a single cylinder to a multi-cylinder engine using bio-renewable fuels at the 2013 DOE AMR. In addition to Scott's award, Ron Graves and Janet Hopson of ORNL also received awards; ORNL received three of the five Vehicle Technologies awards presented at the AMR.

FEERC Researchers Receive 2013 Society of Automotive Engineers (SAE) Engineering Meetings Board Outstanding Oral Presentation Awards
Three FEERC researchers received Outstanding Oral Presentation Awards for their presentations at the 2013 SAE World Congress and Exposition. Brian West, Jim Szybist, and Scott Curran all received awards for presentations given at SAE Congress due to high scores given by other attendees at the conference.

Outreach

FEERC Runners Participate in 2013 Run for Clean Air
A number of runners from FEERC participated in the 2013 Run for Clean 5K run/walk in Knoxville, Tennessee. The event supports the local DOE Clean Cities program, ET Clean Fuels. The event featured a number of alternative fuel and advanced vehicle technology vehicles and had information suitable for both adults and young people. FEERC researcher, Scott Curran, was also on the board of organizers for the event and brought a clean diesel vehicle to display.