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Fuels, Engines, and Emissions Research

Oak Ridge National Laboratory's Fuels, Engines, and Emissions Research Center is a comprehensive laboratory for internal combustion engine technology, specializing in research on paths to higher efficiency, emissions reduction, fuel effects, and emissions chemistry. The applications include engines for transportation, distributed energy, and portable power. Located within the National Transportation Research Center, FEERC performs research spanning fundamental to applied systems. This includes fundamental combustion and catalysis, engine-systems and component technologies, and vehicle-systems. FEERC also works closely with other expertise and facilities at ORNL related to high performance computing, materials characterization, and neutron imaging.

Research Focus

FEERC scientists conduct research on innovative internal combustion engine technologies and control systems for improved efficiency. Combining novel diagnostic and experimental methods with modeling, the Center's scientists also develop improved understanding of the functions and key mechanisms of emission control devices such as lean NOx traps, urea SCR, and diesel particulate filters, with emphasis on improving total system efficiency. These studies also include the impact of fuel properties on advanced combustion processes as well as on emissions and emission control strategies and devices. The range of fuels studied includes gaseous (natural gas) and liquid fuels from conventional and unconventional fossil based sources, as well as non-petroleum fuels from synthetic and renewable sources.

R&D Facilities

FEERC contains seven engine dynamometer test cells that range from 25 to 600 hp. Several have motoring capability. Multiple full-pass engine control systems provide the capability to integrate engine functions with aftertreatment systems, and enable research in combustion management for new combustion regimes. In addition to multiple benches for regulated emissions measurements, FEERC staff and instruments are capable of conducting speciation

Equipment Highlights

- Seven double-ended engine dynamometers
- Three dynamometer stands with one/two cylinder engines
- Vehicle chassis dynamometer
- Analytical chemistry laboratory
- Catalysis function laboratory
- Bench-top exhaust flow simulators
- Fuel cell laboratory
- Access to electron microscopy

Expertise Highlights

- Emissions characterization and speciation, both gaseous and particle
- Non-linear dynamics and controls
- Engine controls
- Combustion
- Catalysis
- Fuels
- Emission control modeling
- Engine fundamentals and thermodynamics
- Predictive engine simulation
- Neutron imaging of transportation techologies

of exhaust constituents in great detail, while striving for fast time resolution. Several configurations of mass spectrometers and chromatographs are in daily operation, as well as fourier transform infrared spectroscopy. Capillary electrophoresis was brought in to analyze urea decomposition products. Exhaust volatile and semi-volatile constituent speciation can be performed. Exhaust particle characterization is accomplished through various methods, including time-integrated mass measurement on filters by tapered element oscillating microbalance, particle sizing by micro-orifice uniform deposit impactor system and scanning mobility particle sizer, composition analysis, and transmission electron microscopy for particle morphology.

In addition to supporting emission characterization, the three analytical labs in FEERC house flow benches and surface spectroscopy instruments for studies of catalyst kinetics and aging mechanisms. FEERC has examples of a very rare and effective configuration of diffuse reflectance infrared spectroscopy and a well-equipped chemisorption apparatus. FEERC scientists also have access to transmission electron microscopy when needed, through the microscopy labs at NTRC and the High Temperature Materials Laboratory.

The SpaciMS, or "spatially resolved mass capillary input mass spectrometry," is an example of a diagnostic tool developed by FEERC staff that has provided extraordinary insights for numerous engine systems and catalyst devices. This analytical tool enables the spatial and temporal resolution of species in functioning environments such as catalyst channels, engine intake/exhaust runners, and fuel cells. It is complemented by fiber-optic based phosphor thermometry, allowing simultaneous species and temperature measurements in catalyst channels. SpaciMS received a 2008 R&D 100 Award and is currently being applied to understand how constituents of intake air might affect vehicle fuel cells.

FEERC also houses a vehicle chassis dynamometer, with approximately 300 hp absorption capacity that can accommodate the advanced emissions instrumentation previously described. The chassis dynamometer has the driver visual aid and control system to perform the standard Federal drive cycle tests.

Partnerships and Collaborations

The FEERC team is highly engaged in both industry and government research on fuels, engines and emissions technologies. They provide leadership with industry through the Crosscut Lean Exhaust Emissions Reduction Simulations (www.CLEERS.org) team, and they participate in US DRIVE and the 21st Century Truck Partnership. In addition to work for others projects, the FEERC team is participating in nine cooperative research and development agreements. They have performed sponsored research for many engine manufacturers, automotive manufacturers, and supplier organizations. They also participate in a memorandum of understanding on advanced engine combustion research with industrial, university, and national laboratory partners. These activities allow scientists at FEERC to stay at the forefront of current engine research and emission controls issues.

ORNL 2012-G00666/tcc