Fuels, Engines, & Emissions Research

The Fuels, Engines, and Emissions Research Center (FEERC) 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. FEERC performs research on all system levels, including vehicle, engine system, component, and basic chemistry and materials levels.

FEERC was designated a DOE National User Facility in 1999; at that time it was named the Advanced Propulsion Technology Center. The name was later changed to more accurately describe the Center's research interests and capabilities. FEERC is located inside the National Transportation Research Center.

Research Focus

Work at FEERC is centered on three interrelated areas of research: fuels, engines, and emissions. FEERC scientists study the impacts 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. The FEERC conducts 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 NO_x traps, urea SCR, and diesel particulate filters, with emphasis on improving total system efficiency.

Expertise

The FEERC team has been developed to encompass the many disciplines necessary for world-class fuels, engines, and emissions-related research, with experimental, analytical, and modeling capabilities. Staff members specialize in areas including combustion and thermodynamics, emissions measurements, analytical chemistry, catalysis, sensors and diagnostics, dynamometer cell operations, and engine controls and control theory.

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

Distinguishing Capabilities

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
- 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

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speciation 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 FTIR (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 (DRIFTS) 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. It has been successfully benchmarked against commercial certification labs (although it is not used for vehicle certification).

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 the FreedomCAR and Fuel Partnership and the 21st Century Truck Partnership. In addition to work for others (WFO) projects, the FEERC team is participating in nine cooperative research and development agreements (CRADAs). 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.

Contact

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1982
Led preparation of the first advanced diesel plan for the Department of Energy

1983
Initiated engine R&D at ORNL

Selected to lead EERE Fuels Utilization Program, significant role continues today

1992-93
First CRADAs in emissions controls/ catalysts

2000
Lead role in preparation of the 21st Century Truck Program Technical Roadmap

Generated experimental data used by EPA in setting rule restricting sulfur in diesel fuel to 15 ppm

2001
One of first open publications of low-temperature combustion regime with simultaneous reduction in NO_x and PM in multicylinder engine

2002-05
Collaboration with EPRI in development of *Flame Doctor®*, applying chaos theory and nonlinear dynamics to combustion diagnostics for industrial burners

2003
Invited member of Engine Combustion R&D MOU

2005
Developed an overarching approach to systematically studying fuels for advanced combustion engines (FACE) and, with NREL, created project and working group in CRC.

2006
Method developed and published for producing hydrogen in diesel engine exhaust in overall lean combustion conditions (for enhanced aftertreatment effectiveness)

2007
Characterized the unstable combustion transition region between spark-ignited flame and HCCI and proposed methods of control based on non-linear dynamic analysis methods

2008
Spatially Resolved Capillary Inlet Mass Spectrometer (SpaciMS) received R&D 100 Award

2009
Development and technology transfer of an instrument for rapid measuring of oil dilution by fuel in operating engines

2005-2010
Demonstration of DOE Vehicle Technologies efficiency and emissions milestones

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