# Unique instruments rev up research on engine efficiency and emissions

The Fuel, Engine, and Emissions Research Center (FEERC, formerly the Advanced Propulsion Technology Center), specializes in the detailed characterization of the efficiency and emissions of internal combustion engines. It is located in the National Transportation Research Center.

The comprehensive capabilities of the FEERC include benchtop engine exhaust simulators, a wide range of dynamometers, and full vehicles. The center boasts several special diagnostic and measurement tools—many of them rarely found at other facilities—that aid researchers in developing and evaluating engine and emission control technologies.

Research areas include an analytical lab, four engine labs with dynamometers, and a chassis dynamometer lab. The analytical lab houses a bench flow reactor, a direct sampling capillary mass spectrometer, a chemisorption unit, and an optical bench. Infrared spectroscopy and laser-phosphor thermography equipment are in adjacent labs.

The four engine dynamometer cells, three of them motored, range from 10 to 600 horsepower. They can be set up to provide highly controlled aftertreatment device performance. The chassis dynamometer has an absorption capacity of ~300 horsepower and can accommodate all the emissions instruments used in the center.

The FEERC staff includes specialists in emissions measurements, dynamometer cell operation, and engine controls and control theory.

Projects currently under way in the FEERC include

- Analysis of the effects of fuel sulfur on diesel emissions controls, diesel and gasoline engine particle emissions, advanced engine control strategies, and catalyst surface diagnostics
- Research on emissions control using $NO_x$ absorber catalysts, selective catalytic reduction, exhaust gas recirculation (EGR), particle filters, and controls with virtual sensing
- Analysis of emissions from ethanol-diesel fuel blends
- Research on catalyst functions and EGR
- Development of innovative ignition concepts
- Study of the time response and sensitivity of $NO_x$ sensors

**Scott Sluder of the FEERC uses a chassis dynamometer to analyze engine efficiency and emissions.**

Researchers from industry and academia can access the unique equipment at the FEERC by executing a User Agreement. This easily executed agreement defines the work to be completed and specifies the ownership of any resulting intellectual property.

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# In industry/state partnership, ORNL analyzes residual stresses in steels

Cummins Engine, one of the largest makers of diesel engines, is using induction heating to make more-reliable and lower-cost engine components. Induction hardening, which treats a material by passing an electric current through it, eliminates lengthy, energy-intensive heat treatment in the manufacture of forged-steel components. The process, however, creates a transition zone in steel components where microstructural and stress gradients occur between the soft, large-grained iron-like core and the hard, fine-grained steel outer surface. These sharp gradients compromise fatigue strength and shorten component life.

As a first step in addressing this problem, ORNL, Cummins Engine, and the state of Indiana supported a project to analyze residual stresses in induction-hardened steels. ORNL researchers examined simple steel specimens provided by Cummins that were treated to produce a transition zone like that in a forged component. They performed metallographic characterizations of an identical companion and similar specimens. Residual stresses were then measured using X-ray and neutron diffraction techniques.

The neutron residual stress measurements clearly showed a sharp transition from the induction-hardened outer layer into the base material (see figure on p. 7). Cummins has used these residual stress data to optimize heat treatment of crankshafts in order to reduce warping and scrap.

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