Accelerating Solutions

From vehicles on the road to the energy that powers them, Oak Ridge National Laboratory innovations are advancing American transportation.

OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Oak Ridge National Laboratory is making an impact on everyday America by enhancing transportation choices and quality of life. Through strong collaborative partnerships with industry, ORNL research and development efforts are helping accelerate the deployment of a new generation of energy efficient vehicles powered by domestic, renewable, clean energy.

EPA ultra-low sulfur diesel fuel rule

ORNL and the National Renewable Energy Laboratory co-led a comprehensive research and test program to determine the effects of diesel fuel sulfur on emissions and emission control (catalyst) technology. In the course of this program, involving at least 20 industry and government organizations, ORNL conducted a key experiment in year 2000 that demonstrated feasibility of achieving 2009 emissions standards in a diesel car. The Environmental Protection Agency cited this research in a 2000 diesel sulfur rulemaking that would lower diesel fuel sulfur content to a maximum of 15 ppm. Every gallon of highway diesel fuel now sold in the US was impacted by this research, enabling much cleaner and efficient diesel engines for cars and trucks.

ORNL researchers used a 1999 Mercedes A170 CDI and prototype catalysts from industrial partners to demonstrate a potential path for light-duty diesels to achieve US Tier-2 emissions levels with ultra-low sulfur diesel fuel.

EGR cooler fouling and corrosion

Although many aspects of the research remain confidential, the research to understand fouling and corrosion of exhaust gas recirculation (EGR) coolers, now used on most vehicles, is being used in emission control system design, modeling, and calibration processes. Twelve companies are working with DOE and ORNL via the Diesel Crosscut Team guidance. Key scientific strengths in analytical chemistry, microscopy, and neutron imaging have been applied in highly controlled engineering experiments to elucidate the fouling processes. Selected parts of the effort have been shared openly in joint publication by ORNL and industry partners.

Power electronics and electric propulsion

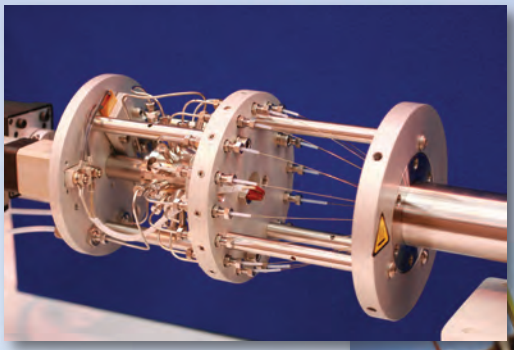
ORNL is partnered with industry in four projects in power electronics and electrical power systems research supported by DOE's Advanced Research Projects Agency – Energy. These ARPA-E projects, aimed at accelerating electrification of transportation, include fast-track development and commercialization of an affordable rare-earth-free electric vehicle motor and electric vehicle chargers that are smaller, more powerful, and energy efficient. ORNL is also helping lead ARPA-E grid-modernization efforts to redesign the way electricity is delivered while saving energy and money.

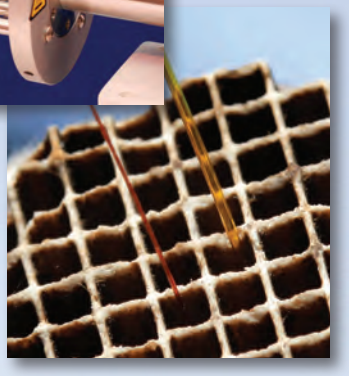
SpaciMS

Spatially resolved capillary inlet mass spectrometer (SpaciMS) characterizes exhaust constituents in vehicle catalysts, providing detailed insights into chemical processes through fast-response, noninvasive gas composition measurements. It accelerated light-truck diesel development and deployment in a leading consumer pickup truck, helping meet 2010 emissions standards in 2007.

"This instrument, unique in its ability to rapidly measure spatially resolved gas composition in almost any environment including inside catalyst channel, changed the way we think about tuning engine combustion. With the advent of diesel aftertreatment systems, the speciation of exhaust gases became critical to the function of the engine/aftertreatment system. The SpaciMS allowed us to quantify speciation in a way that previous instrumentation did not and now is a mainstay of our aftertreatment system development."

– John C. Wall, Vice President/Chief Technical Officer, Cummins Inc.





SpaciMS won a R&D 100 Award and was commercialized by Hiden Analytical.

Battery performance

General Motors and the High Temperature Materials Laboratory User Program have developed a customized nondestructive monitoring technique for analyzing the large format lithium ion batteries used in GM's electric vehicles. Using neutron scattering and high resolution infrared imaging, they conducted in situ analysis of cathode and anode materials inside fully functioning lithium ion cells. The techniques used in this project are a significant advance over conventional tools and techniques and will be applicable in other research projects. The information obtained during the project will help GM ensure that the performance of production batteries is consistent with that predicted from laboratory studies.

Fully-carbonized fiber exiting the microwave assisted plasma carbonization unit.

Carbon fiber

Carbon fiber research that began with centrifuge technologies of the 1980s is leading to the industrialization of carbon fiber composite materials in transportation technologies through advances in conversion, processing, predictive tools, and streamlined approaches for design optimization and durability. For example, research by ORNL and partner Dow Chemical Company is being leveraged to support a joint development effort between Ford Motor Company and Dow Automotive Systems, a business unit of Dow Chemical Company, to research the use of advanced carbon fiber composites in high-volume vehicles. DOE awarded ORNL $35 million in American Recovery and Reinvestment Act funding in 2009 for construction of a carbon fiber technology center, scheduled to open in 2013.

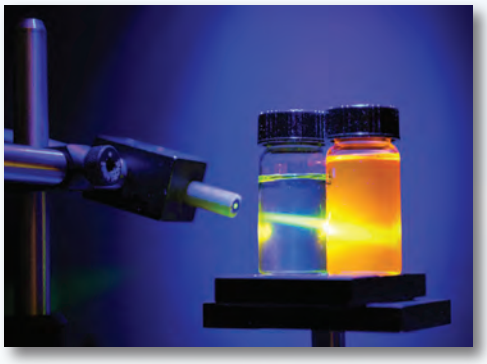
Close-up of shaft wheel assembly.

Life and reliability of vehicle components

Partnering with the High Temperature Materials Laboratory User Program, Honeywell Turbo Technologies conducted neutron and X-ray scattering characterization studies at the High Flux Isotope Reactor to collect residual stress measurements of the shaft wheel assembly weld joints of vehicle turbochargers used in both automobiles and trucks. By quantifying the role that residual stresses play in the lifetime of the shaft wheel assembly and turbocharger housings, the experimental data will aid Honeywell in designing the highest quality shaft wheel assemblies and monitoring manufacturing processes. Future collaborations with Honeywell include the evaluation of cost-effective ways to mitigate residual stress and thereby extend component life and ensure reliability of both the shaft wheel assembly and turbine housing in the company's turbochargers.

Fuel in Oil diagnostic technology

Fuel in Oil technology provides fast, real-time, on-engine assessment of oil contamination by fuel. The technology enables improved engine calibration for greater efficiency and durability. This technology received a 2011 Federal Laboratory Consortium Award and has been licensed to Da Vinci Emissions Services.



Fuel in Oil technology enables improved engine calibration for greater efficiency and durability.

Mileage accumulation dynamometers at subcontractor facilities were used to "age" many of the vehicles being researched.

EPA waiver on E15

Intermediate Ethanol Blends Test Program, a DOE-industry collaborative that was co-led by ORNL, is referenced in an EPA ruling to allow E15 gasoline in 2001 and newer model cars. The three-year study evaluated the effects of E15 and E20 fuels on the emissions and performance of vehicles and non-road engines, as well as infrastructure materials.

Revolutionary steel used in regeneration system

CF8C-Plus cast austenitic steels developed by ORNL are low-cost, high-performance alternatives to conventional cast steels. Caterpillar uses 500 tons of CF8C-Plus steel to make the regeneration system burner housing for diesel particulate filters, saving millions of dollars over the cost associated with Caterpillar's older-generation housings incorporating nickel-based superalloys. Caterpillar's Regeneration System employs the technology in 35,000 heavy-duty highway diesel engines.

CF8C-Plus is used in Caterpillar's regeneration system burner housing for diesel particulate filters.

HEV component benchmarking

ORNL researchers are not just building new technologies; they're taking apart existing technologies to understand more about what makes them successful and to identify improvement opportunities for industry. ORNL hybrid electric vehicle component benchmarking capabilities are highly valued by industry in HEV powertrain development, as cited regularly by US Drive Partners.

Benchmarking existing technologies can help uncover improvement opportunities in developing technologies.

Billion Ton Study

ORNL led DOE's first Billion Ton Study for the Department of Agriculture in 2005. It played a pivotal role in the development of the Energy Independence and Security Act of 2007, confirming the technical feasibility of US lands supplying a billion tons of biomass annually. ORNL completed a second report for DOE in 2011 that expands on the first to include a spatial, county-by-county inventory of potentially available primary feedstocks, price, and available quantities for the individual feedstocks, and a more rigorous treatment and modeling of resource sustainability.

Materials expertise and rapid response

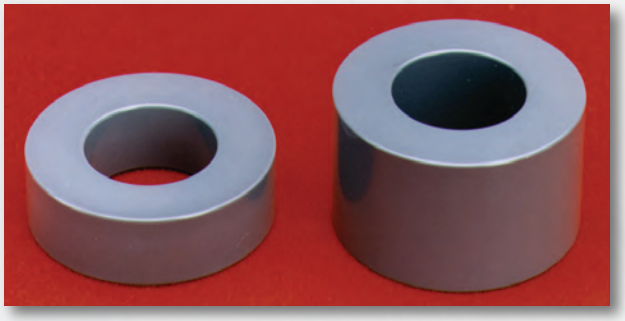
ORNL, through its High Temperature Materials Laboratory User Program, assembled a rapid-response team to assist Cosma International, a global automotive parts manufacturer and subsidiary of Magna International, in resolving a component materials issue that briefly interrupted its Clinton, TN operations as well as those at an OEM production plant.

Magna and Cosma officials wrote to Secretary of Energy Steven Chu in March, praising HTML's quick response and unique capabilities. In the letter, General Manager Steve Esman and Quality Manager Allan Navarro note that they turned to HTML for its expertise, powerful tools, and "most importantly the staff's understanding of the relationships between manufacturing processes and the microstructure and physical and mechanical properties of materials."

ORNL researcher prepares the surface of the A-pillar inner post on the drive side of a body in white to determine its state of residual stresses.

Stronger diesel filter

General Motors-ORNL CRADA work is unraveling why diesel particulate filters (DPFs) often perform better than models predict. Measurements have revealed the apparent elastic modulus of DPF ceramics to be almost an order of magnitude lower than industry-accepted values. With the new information, manufacturers can more accurately model performance and expect longer service lifetimes than ever before.



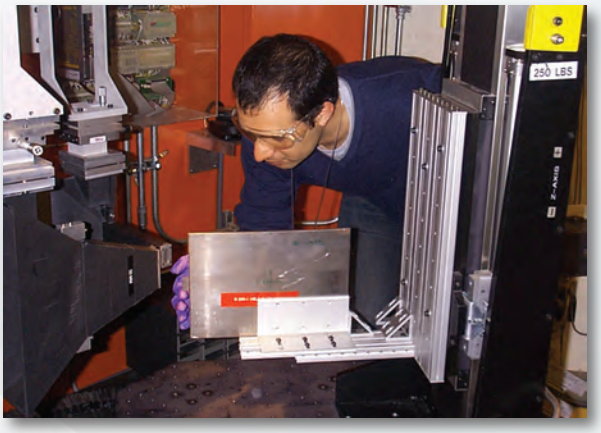
Silicon nitride cam-roller followers.

Silicon nitride truck parts

ORNL work to improve the silicon nitride used in cam-roller followers helped reduce exhaust emissions from large diesel engines in highway trucks. Cam-roller followers are part of the mechanical chain that creates high fuel pressures, which must withstand high stresses. This improved silicon nitride, now produced by Ceradyne, has been used to make cam-roller followers for Detroit Diesel Corporation.

Forged aluminum rotors for turbo chargers

ORNL's rapid infrared heating technology incorporates advanced atom probe and electron microscopy characterization techniques, enabling the development of a rapid, energy-efficient, and low-cost heating methodology. The technology is used by Queen City Forging Company to produce high-quality forged aluminum rotors for turbochargers, which improve the fuel economy of diesel engines in lieu of turbochargers using heavier titanium rotors purchased abroad.



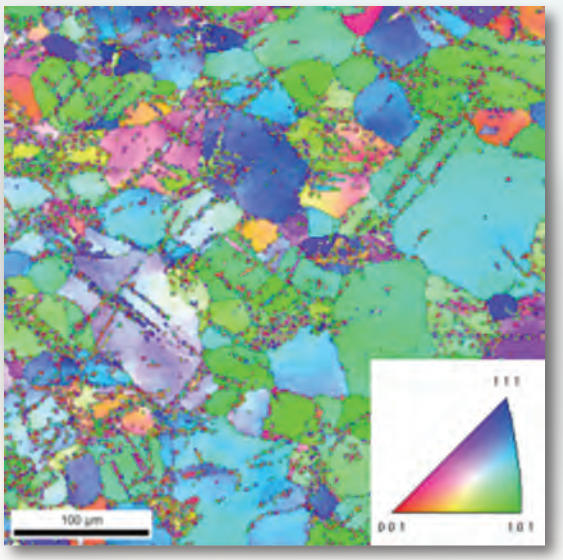
Metalsa researcher mounts a plate sample for through thickness strain mapping as a function of distance from the hole along a line transverse to the rolling direction of the plate.

Validation of mass weight reduction process

Metalsa, which supplies side rails and chassis components to over 50% of the North American heavy truck market, used a High Flux Isotope Reactor beam line managed by ORNL's High Temperature Materials Laboratory User Program to validate a hole-cutting method for reducing side rail weight. The process represents 100–200 pounds per truck or an annual savings of up to 30 million pounds of steel. Savings on 150,000 trucks driving 100,000 miles per year is estimated to be 3.8 million gallons each year.

Automotive structure improvements

Magnesium Elektron North America researchers came to the High Temperature Materials Laboratory to work on a user project focused on two goals: enhancing formability of sheet alloys and producing lighter weight automotive components. Experimental data were collected to help determine the manufacturing process adjustments needed to improve magnesium sheet formability. Characterization results from both electron backscatter and x-ray diffraction will enable Magnesium Elektron to design manufacturing processes for large-scale production of magnesium alloys for automotive structures.



Electron backscatter diffraction microscopy image reveals different grain orientations by color, as well as the presence of shear bands (linear features cutting across grains). The inverse pole figure map (inset) provides a key to the color-crystallographic orientation relationship.

Collaborations for efficient engine emission controls

ORNL helped create and continues to co-lead the Crosscut Lean Exhaust Emission Reduction Simulation forum. DOE has described CLEERS as underpinning their research strategy for efficient engine emission controls. Work in the forum has provided numerous findings and contributions to catalyst-based emission controls. In National Academy of Sciences reports on 21st Century Truck and FreedomCAR partnerships, CLEERS has been repeatedly cited for its technical contributions and value to industry. The findings are generally used by the participants from the auto OEMs, catalyst suppliers, and engine companies.

Inside dry room at Dow Kokam's new Global Research and Development Center.

Battery manufacturing

ORNL support for CRADA partner and battery manufacturer Dow Kokam is producing successes. One example, ORNL process development was used to manufacture electrodes in Dow Kokam test cells, enabling domestic supply chain and 93% capacity retention after 50 cycles.

"The support from partners like the DOE and ORNL reinforces the strength of Dow Kokam's R&D strategy focused on leading edge flexible energy storage solutions that meet the unique needs of a wide range of industries. The market is rapidly expanding, and the demand for advanced battery solutions is growing; our collaboration with the US government and technology institutions is an essential complement to our in-house R&D capabilities."

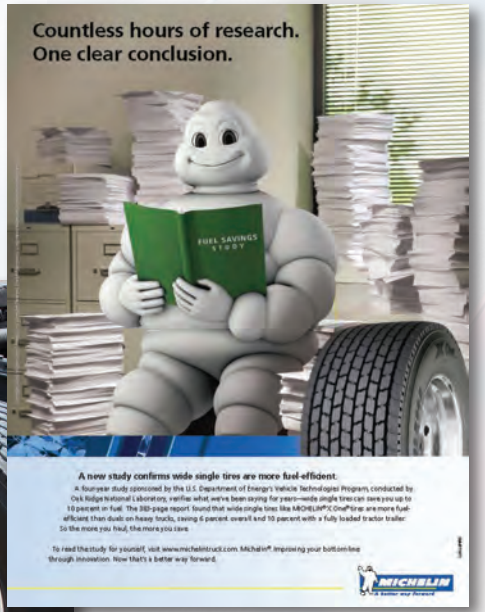
– Dow Kokam Vice President of Technology Joon Kim

Lean idle control

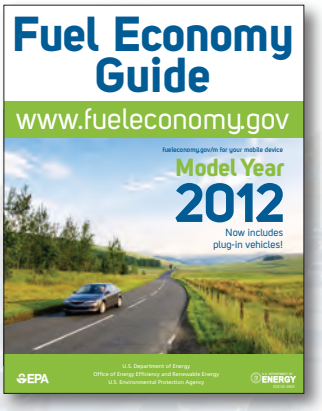
Development of new insight into nonlinear engine processes for improved control led to a patent with Ford Motor Company on lean idle control and a CRADA with Delphi.

Tire-related fuel efficiencies

An ORNL-led study found leading manufacturer Michelin's wide-based single truck tires to be up to ten percent more fuel efficient than dual tires. The study is one example of ORNL heavy truck and medium truck duty research that is helping industry identify and solve problems related to performance, safety, efficiency, etc. Michelin used the results in an ad campaign promoting this fuel-saving technology.



Advertisement from Michelin campaign promoting wide-based single truck tires.



Consumer decision-making tools

DOE efforts designed to help decision makers save fuel and cut down on pollutant emissions by exploring energy use under various transportation scenarios and vehicles led to ORNL management of the DOE-EPA fueleconomy.gov Web site and Fuel Economy Guide publication.

Exhaust gas corrosiveness detection

ORNL adapted a corrosion probe to use in operating development engines to aid manufacturers in assessing and selecting calibration points based on corrosion potential of exhaust gas recirculation. The method and instrument were deployed at two or more engine companies around 2002, but the work was proprietary and not published. ORNL published a paper that described the method with non-proprietary data in 2005.

Exhaust gas corrosion probe has been deployed at several engine companies.

Industry Partners

ORNL has and continues to participate in numerous CRADAs for advancing vehicle technologies. Many aspects of research may not be publically available, but most likely influenced product development.

- Ford
- Cummins
- Detroit Diesel Corporation
- Navistar
- John Deere
- Delphi
- Reaction Design
- Caterpillar
- General Motors
- Dow Kokam

For more information…

See the following publications to learn more about the ORNL research successes highlighted in this brochure.

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Contact Information

Sustainable Transportation Program
Oak Ridge National Laboratory

Program Office Address

National Transportation Research Center
2360 Cherahala Blvd.
Knoxville, TN 37932
Phone: 865.946.1861
Fax: 865.946.1214
E-mail: transportation@ornl.gov
www.ornl.gov/ees/transportation

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