On the Track to a Greener, Cleaner Locomotive Engine
Research partnership aims to improve fuel efficiency, reduce emissions, and cut costs
Chuck Horton, Manager of Advance Technologies, General Motors Electro-Motive Division, talks about working with Argonne’s Engine Research Facility to evaluate the performance of a new four-stroke diesel locomotive engine before it’s ready for the market. Page 2

Talkin’ Trash to Reduce Waste
Polymers can be reclaimed from scrapped automobiles
Synthetic polymers constitute about 20-30% of the 3-5 million tons of automobile shredder residue generated each year. New processes can separate out those polymers for recycling. More recycling means less waste for landfills and more cost savings. Page 3

FutureCar Teams Rev Up to Improve Automobiles
Students redesign sedans for better fuel efficiency, lower emissions
Teams from 12 top engineering schools attempted to push the fuel efficiency of a midsize family car to the limit while maintaining safety, consumer acceptability, low emissions, performance, and affordability. The team from the University of California at Davis placed first with a converted 1996 Ford Taurus hybrid-electric vehicle that achieved 49 miles per gallon equivalent (mpge) combined fuel economy, 40 mpge city cycle, and 62 mpge highway cycle. Page 4

“Green” on Gasoline?
Catalyst-based fuel processor would let fuel-cell cars run on conventional fuels
Fuel cells have many advantages as power sources for electric vehicles, but they need hydrogen to work. Argonne’s new “fuel reformer” can extract 80-90% of the hydrogen from hydrocarbon fuels, such as gasoline, which allows them to be used as a power source for fuel cells. Page 5

Ultra-Low-Friction Coatings Could Be an Engine’s Best Friend
Extremely hard carbon provides long-term wear resistance
Ultra-low friction, combined with other unusual mechanical and chemical properties, makes Argonne’s new carbon coatings ideal for many transportation applications. These amorphous carbon coatings have a friction coefficient of less than 0.001; by comparison, Teflon’s friction coefficient is about 0.04. Page 6

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On the Track to a Greener, Cleaner Locomotive Engine

Research partnership aims to improve fuel efficiency, reduce emissions, and cut costs

As railroads cope with pressure to reduce emissions and cut costs, locomotive manufacturers must respond to those customer needs as they design new engines. General Motors Electro-Motive Division (EMD), one of the world’s leading manufacturers of heavy-duty diesel engines for passenger and freight locomotives, is working with Argonne to address those issues.

Chuck Horton, Manager of Advance Technologies at EMD, has been pleased with the association: “Many different, competent engine design and consultant companies are available. We considered these firms but chose Argonne as our partner not only because of its nearby location but also for its flexibility. Argonne can bring in experts from other companies or national laboratories to have the right team for a particular research task.”

Horton feels the working relationship is synergistic: “In an industrial setting, production pressures can interfere with research. But at Argonne, research is the top priority. This partnership enables us to give our research the attention it deserves, away from day-to-day business needs, and Argonne benefits from industry-developed expertise in commercializing new technology.”

EMD’s newest design is the four-stroke, 6,000-horsepower, direct-injection diesel locomotive engine — the “H” engine. A one-cylinder version of the engine has been installed in Argonne’s new Engine Research Facility so that engineers can analyze the basic design and find ways to continually improve performance and reliability, increase fuel efficiency, and reduce harmful exhaust emissions. Horton says future plans include a multicylinder facility to confirm that research results from the single-cylinder engine will satisfactorily apply to the multicylinder engine as a system: “Our goal is to discover and evaluate new technologies to determine their technical feasibility and commercial viability.”

Argonne’s Work-for-Others contract with EMD is part of a broader transportation initiative that includes a partnership with the railroad industry to improve energy efficiency, clean up the environment, strengthen infrastructure, and maintain industrial competitiveness. The results of earlier research are being applied to the work for EMD and could also have applications far beyond the “H” engine — the materials and technologies developed during this project could help speed the search for cleaner and more cost-effective diesel engines, which can benefit the entire U.S. transportation industry.

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Talkin’ Trash to Reduce Waste
Polymers can be reclaimed from scrapped automobiles

Someday we’ll be able to recycle the polymers from our old cars as completely as we now recycle the plastics from our household trash. New technology being developed at Argonne will help recover reusable polymers from junked automobiles. More recycling means less waste for landfills and more cost savings.

Synthetic polymers constitute 20-30% of the 3-5 million tons of automobile shredder residue generated each year. These materials are not currently reused because of the lack of a cost-effective recycling technology and the difficulty of separating shredded waste into its component parts. Two new processes may change this situation.

One process uses several techniques to separate the shredder residue into its components: polyurethane foam, which is then cleaned and reused; metallic “fines,” which can be a source of iron oxide; and a plastics-rich stream, from which heat-formed plastics can be recovered. A pilot plant has been designed and built by Argonne. The plant has produced three tons of polyurethane foam, which has been used successfully to make carpet underlayment and sound-reducing material. These products have been tested and found to meet industry specifications.

Another Argonne-developed process may also be applicable to automobile shredder residue. A modified froth-flotation process is being evaluated for separating commingled plastics from shredded appliances. Laboratory tests have shown that the process can produce 99%pure acrylonitrile-butadiene-styrene and high-impact polystyrene. A larger demonstration is under way at Appliance Recycling Centers of America (Minneapolis, Minnesota). The pilot plant can process 800 pounds of commingled plastics per hour. Bench-scale tests have demonstrated that the froth-flotation process can also be applied to separate plastics from automobile shredder residue. (Info package 7103)
FutureCar Teams Rev Up to Improve Automobiles

Students redesign sedans for better fuel efficiency, lower emissions

Think a family car can be transformed to provide three times the fuel efficiency currently offered without sacrificing performance? The students who participate in the FutureCar Challenge do — and they’re well on their way. One team reached a combined fuel economy of 49 miles per gallon equivalent (mpge) in mileage tests; another achieved 56 mpge on the road.

Twelve top engineering schools competed in the 1997 FutureCar Challenge held June 3-11. Their goal was to use advanced automotive technologies to push the fuel efficiency of a midsize American family sedan to the limit while maintaining safety, consumer acceptability, low emissions, performance, and affordability.

FutureCar teams competed in a variety of events at the General Motors Technical Center in Warren, Michigan, including tests of emissions, handling, consumer acceptability, and use of advanced materials and technologies. The competition ended with a two-day, over-the-road endurance run from Detroit to Washington, D.C. As the FutureCars crossed the finish line at the U.S. Department of Energy (DOE), Secretary Federico Peña greeted them by saying, “Your achievements will soon provide even more proof that what is good for the environment is also good for the economy.”

The team from the University of California at Davis placed first with a converted 1996 Ford Taurus hybrid-electric vehicle. The UC-Davis team also received a special award for the most energy-efficient vehicle (49 mpge combined economy, 40 mpge city cycle, and 62 mpge highway cycle). The Virginia Tech team placed second with a 1996 Chevrolet Lumina converted to a fuel-efficient, propane-powered hybrid vehicle. Virginia Tech also topped the field in consumer acceptability. Third place went to the team from the University of Wisconsin, which took a 1996 Dodge Intrepid and converted it to a diesel-powered hybrid. That Wisconsin entry also demonstrated the best over-the-road fuel economy, achieving an impressive 56 mpge (complete results are reported on the Web at http://www.uscar.org/futurecar/index.html).

The DOE sponsors several student competitions each year with help from auto manufacturers and organizations such as Natural Resources Canada and the U.S. Environmental Protection Agency. As a DOE national laboratory, Argonne develops and manages these competitions from initial concept through post-race events.

To subscribe to FutureDrive, a free newsletter that focuses on advanced transportation technology competitions sponsored by DOE and its partners, send e-mail to ckaicher@anl.gov.

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Participating Schools

California State University-Northridge
Concordia University
Lawrence Technological University
Michigan Technological University
The Ohio State University
University of California at Davis
University of Illinois at Chicago
University of Maryland
University of Michigan
University of Wisconsin
Virginia Tech
West Virginia University
"Green" on Gasoline?
Catalyst-based fuel processor would let fuel-cell cars run on conventional fuels

In the eyes of many consumers, battery-powered electric cars demand too many adjustments in driving habits, because they require recharging and have limited range.

Enter electric vehicles powered by fuel cells. These cars can be as “green” as battery-powered ones, without many of the disadvantages. Fuel cells make electricity as long as they have a supply of hydrogen and air. The only waste products are water and heat. “Think of them as batteries that can be continuously recharged by supplying fuel,” says Argonne scientist Shabbir Ahmed.

However, a significant challenge in developing fuel-cell vehicles has been finding an effective way to provide hydrogen. It is an unwieldy fuel with no widespread refueling infrastructure. With a new approach developed at Argonne, getting hydrogen for your fuel-cell-powered electric car could simply mean filling up at the nearest service station as you always have — no habits to change.

The Argonne approach centers on a catalytic fuel processor, or “reformer,” that extracts hydrogen from liquid hydrocarbons, such as methanol or gasoline. All it needs to run is fuel, water, and air.

The device promises a significant advance in development of fuel-cell vehicles. “Most groups have been working on improving the fuel cell and the electric drivetrain. What we’ve done is take a step forward on the next big challenge: what fuel to use. People are very interested in using conventional liquid fuels, especially gasoline,” says Kevin M. Myles, Director of Electrochemical Technology Programs at Argonne.

The key to the fuel processor is a new class of catalysts. These materials, synthesized at Argonne and being patented, have unique properties that allow them to selectively oxidize carbon. This ability gives the fuel processor the flexibility to operate on a wide range of fuels, including natural gas, liquefied petroleum gas, ethanol, methanol, and gasoline. Also, the catalytic approach has many engineering advantages that will make the reformer efficient, dynamically responsive, small, and potentially inexpensive to manufacture, and thus attractive for automotive use.

In laboratory-scale testing, the new catalyst successfully converted commercial gasoline and commercial natural gas into a hydrogen-rich product at temperatures less than 750°C. The process extracts 80-90% of the available hydrogen in the feed. This nearly complete initial extraction means that secondary processing units can be smaller and lighter.

An engineering-scale reformer for methanol has already been demonstrated with a commercial copper-zinc oxide catalyst. The team is now testing the new catalyst with various liquid fuels in a laboratory unit that’s one-fifth the size needed for a vehicle. They will soon integrate the reformer and any aftertreatment processes into hardware that will supply hydrogen pure enough for optimal fuel-cell performance. (Info package 7208)
Ultra-Low-Friction Coatings Could Be an Engine’s Best Friend
Extremely hard carbon provides long-term wear resistance

Friction-reducing coatings are often applied to moving parts that slide, roll, or rotate, such as engine components. However, these coatings may be difficult, time-consuming, or even impossible to deposit on materials such as plastics, ceramics, and certain metals. And they may not be durable enough to hold up under strenuous use.

Argonne has developed a near-frictionless carbon film coating that is almost as hard as diamond. Ultra-low-friction carbon (UFC), a form of amorphous carbon, has a friction coefficient of less than 0.001; by comparison, Teflon’s friction coefficient is about 0.04. Thin (1 micrometer) UFC films can be deposited on virtually any substrate by ion-beam deposition, sputtering, or chemical vapor deposition at low temperatures (room temperature to 200°C) — without the risk of damaging heat-sensitive materials.

UFC coatings combine unusual mechanical and chemical properties that make them ideal for a wide variety of engineering applications:

- Very low friction
- Extreme hardness
- High wear resistance
- Corrosion resistance
- Virtual transparency
- Good electrical conductor or insulator

The combination of extreme hardness with ultra-low friction in UFC films provides long-term wear resistance and lubrication to reduce material and energy losses. Specific benefits include the following:

- Near-perfect finished products that do not require secondary machining or grinding
- Increased lifetime and improved performance in rolling, sliding, and rotating components
- Ultra-hard and extremely slick coatings for sliding parts and machining of high-precision surfaces
- Higher productivity, lower costs, and improved environmental compliance (reduction or elimination of flammable and hazardous metalworking fluids)

UFC coatings could be used in many automotive applications:

- Piston rings (reduced wear at higher cylinder pressures)
- Gears and bearing components (improved durability; smaller, light components)
- Camshafts and cam-roller follows (increased resistance to rolling-contact fatigue)
- Fuel injectors (higher injection pressures)
- Air-conditioning compressors (greater durability of components used with R-134a refrigerant)

Working with manufacturers of diesel engines and automotive gas turbines, Argonne researchers are developing processes for depositing UFC films on metal and ceramic engine components. Recent studies have revealed that UFC films can be applied to aluminum and titanium alloys and a variety of plastics. One new process uses ions to literally hammer thin films onto surfaces. This process yields coatings that adhere extremely well. The resulting coated parts provide low friction and high wear resistance in mechanical applications involving rolling, sliding, and rotating contacts.

For more information, contact George Fenske, phone: 630-252-5190; fax: 630-252-4798; e-mail: gfenske@anl.gov, or Ali Erdemir, phone: 630-252-6571, fax: 630-252-4798, e-mail: a_erdemir@qmgate.anl.gov.

Argonne is also testing the performance of the films over a wide range of loads, speeds, and temperatures to reduce friction and improve wear and corrosion properties in components for low-emission, high-fuel-efficiency transportation systems. (Info package 6207)
I never cease to be amazed when people tell me that they never realized that Argonne National Laboratory is involved in a particular field of research. I can only conclude that we haven’t done a very good job of letting people know about our work. This newsletter is one way we hope to let more of you know what the Laboratory is doing in transportation research.

Argonne’s transportation research spans a broad range of technologies: from advanced materials to alternative fuels, from the cleanest of propulsion systems (fuel cells) to innovative emissions controls for current gasoline and diesel engines, from supercomputing for designing safer vehicles to recycling existing and new materials for the family car, from improving today’s batteries to meet the requirements of electric vehicles to developing new energy storage devices (flywheels and ultracapacitors) that could be used in hybrid vehicles — Argonne is conducting research today to meet the nation’s transportation needs tomorrow.

TransForum is intended to be what the name implies: a place for free discussion of transportation ideas. You will find brief summaries of recent research in Argonne’s Transportation Technologies program, a short interview with an industry or government representative on key research issues, and highlights of some of the accomplishments of the research staff.

Topics will vary from issue to issue and certainly cannot be covered in depth in these few pages, but if you find something that may meet your technology needs, please contact us for more information. You’ll find our names, numbers, and e-mail addresses throughout this newsletter. We want TransForum to be an information exchange: it’s a two-way street. Let us hear from you.

Larry R. Johnson
Director

LOOKING DOWN THE ROAD

Vice President Al Gore has recognized three Argonne scientists, Lennox Iton, Ismat Jahan, and Victor Maroni, for their contributions toward a cleaner, more efficient automobile engine. They were among a group of scientists and engineers honored during a White House ceremony for their progress in developing technologies for advanced catalytic converters. The Argonne team investigated the use of advanced catalysts for engines that could decrease nitrogen oxide emissions in automobile exhaust by 50%. This research is part of the Partnership for a New Generation of Vehicles, an industry/government effort to create a vehicle with a fuel efficiency of up to 80 miles per gallon without sacrificing affordability, performance, or safety.

Two Argonne staff members have been elected to serve on Society of Automotive Engineers International (SAE) governing bodies. Bob Larsen was elected to the SAE International Board of Directors for a three-year term starting in 1998. He is the first SAE director associated with a federally funded organization. Frank Stodolsky has been named Vice Chair of SAE’s Advanced Power Plant Committee for a one-year term. Typically, the Vice Chair becomes Chair at the end of the term.

Dan Santini has been elected Chair of the Transportation Research Board’s (TRB’s) Alternative Fuel Committee for a three-year term, extendable to six years. He will manage the review of papers on alternative fuels and arrange summer conferences in conjunction with other TRB committees, particularly the joint conference on transportation, energy, and environment with the Energy Committee.
Argonne is seeking industrial partners to develop advanced transportation technologies. The following types of working arrangements can be made:

- In a Work-for-Others agreement, Argonne’s industrial partner pays the full cost of the research performed. The company generally takes title to any inventions, and proprietary information and research results are kept confidential.

- In a Cooperative Research and Development Agreement (CRADA), Argonne and its industrial partner share the costs of research. The company may obtain rights to intellectual property developed by Argonne. Proprietary information is kept confidential, and research results may be protected from disclosure for up to five years.

- Licenses for Argonne inventions and software may be granted to companies that wish to develop them into marketable products or processes. Licenses may also be part of CRADAs or Work-for-Others agreements.

- Personnel exchanges and technical assistance projects can be arranged with Argonne for short-term or rapid-turnaround work.

For more information about working with Argonne, contact:

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