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TransForum

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VIEWPOINT

Gearing Up for HEV Powertrain Design

DOE's Bob Kost expects new test facility to make system integration faster, less expensive

The new Advanced Powertrain Test Facility allows researchers to swap out hybrid-electric-vehicle components and try new configurations without tearing down the whole system each time. The facility's dynamometer is operated by a computer system that simulates vehicle behavior under different driving conditions. And emissions testing is built right into the process. *Page 2*

RESEARCH REVIEW

Taking a Closer Look into How Batteries and Fuel Cells Work

Imager maps electrochemical reactions crucial to improved performance

Electrochemical reactions in the paper-thin region just beyond the electrodes can make or break the performance of a battery or fuel cell. A new near-electrode imager combines an electrochemical cell and a nuclear-magnetic-resonance chemical analyzer to take stunningly detailed "snapshots" of these reactions. *Page 3*

ITS Makes Life in the Fast Lane Easier

Intelligent transportation systems combine technologies to improve traffic flow

Traffic congestion costs Americans about $100 billion in lost productivity and contributes to about 40,000 deaths and 5,000,000 injuries each year. Intelligent transportation systems can help alleviate this problem. Argonne is working with its partners to link global positioning system satellites, traffic control centers, traffic signals, and "smart vehicles" to use up-to-the-minute information to move traffic better. *Page 4*

"Wrapping It Up to Go": Transporting Hazardous and Radioactive Materials Safely

Safety requirements, technical evaluation, and education go a long way in protecting the public and the environment

A multidisciplinary team helps to ensure that hazmat shipments pose no threat to people and the environment along transportation routes by evaluating packaging, assisting in developing standards, and offering training courses. *Page 5*

On-Line Monitor Ensures Strong Laser-Beam Welds

Low-cost sensor checks welds in process and reduces waste

A new monitor for laser welding operations measures infrared emissions from welds during processing. The monitor flags bad welds and automatically signals the system to change weld parameters or laser power levels. And it costs only about $15,000, much less than the $50,000 price tag of a more conventional system that cannot monitor welds on-line. *Page 6*

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Gearing Up for HEV Powertrain Design

DOE's Bob Kost expects new test facility to make system integration faster, less expensive

Build a car, test it, tear it up, try again — this approach to design works great if you're a hobbyist. But for manufacturers racing to bring advanced vehicles to market, it just isn't fast enough and it can be costly.

Robert Kost (DOE), Bob Larsen and Mike Duoba (Argonne), Patrick Sutton (DOE), and Keith Wipke (NREL) view an engine installed in Argonne's Advanced Powertrain Test Facility.

"The role of the U.S. Department of Energy is to remove barriers that keep new technologies out of the marketplace," states Robert Kost, DOE's Vehicle Systems Team Leader. That's the philosophy behind Argonne's new Advanced Powertrain Test Facility (APTF), where researchers don't even have to build a car to test hybrid-electric-vehicle (HEV) powertrain components.

An HEV propulsion system has two power sources: an electric motor and a fuel-using device, such as an internal combustion engine. Combining them into a single powertrain is a challenge. Kost explains: "HEV components are being developed by individual suppliers working independently. These components perform differently when working together in a system than when tested individually. We need to solve the integration problems. The APTF will allow us to provide feedback to those suppliers about how their technologies perform in a system with other components, to aid in their further development."

Bob Larsen, Argonne's manager of fuels and vehicle systems research, agrees: "The biggest difficulty with building HEVs is that there are so many degrees of freedom in the engineering design. By mapping the characteristics of each component, then combining them into a drivetrain, we can find an optimized hardware configuration and control strategy. This capability will help automakers and suppliers speed up the introduction of production HEVs."

"We also need to lower the costs of these new technologies for faster change," Kost adds. "HEVs are technically feasible now, but they also need to be cost-effective. The APTF is a much less expensive way to see how components perform together. During the next year or two, we'll be getting results that will help us decide where best to focus our future research dollars."

At the heart of the APTF are a 190-horsepower motoring DC engine dynamometer and an Argonne-designed control computer and data collection system. Together they drive the powertrain through test cycles, simulating the changing behavior of vehicles with different aerodynamics under various driving conditions. Simultaneous emissions testing is built in. The completely modular facility allows parts to be exchanged quickly, for rapid, standardized assessment. Components such as engines, fuel cells, electric motors, transmissions, and generators can be benchmarked individually or as part of an integrated system. A chassis dynamometer will be added by year-end.

Dedicated in December 1997, the APTF currently supports DOE programs and contracts. Planned research includes tests of gasoline and advanced direct-injection diesel engines such as the Toyota "D4" engine, advanced battery performance, and fuel cell configurations. The facility will also be available to industrial partners. Larsen says, "We're looking to establish working partnerships with suppliers who may not have the resources to build an actual vehicle to test their components."

A computer screen displays test data from an HEV powertrain.

For more information, contact Bob Larsen, phone: 630/252-3735, fax: 630/252-3443, e-mail: blarsen@anl.gov.

Taking a Closer Look into How Batteries and Fuel Cells Work

Imager maps electrochemical reactions crucial to improved performance

Argonne imager quickly and clearly reveals critical changes in electrolyte composition that may be responsible for reduced performance.

For electric vehicles (EVs), one barrier to commercial success is paper-thin. That's the size of a region just beyond the electrodes of a battery or fuel cell — 100 micrometers (0.004 inch, or the thickness of a sheet of paper) — where critical electrochemical reactions occur. These reactions can make or break the performance of these power sources.

However, finding out what's going on in that region has been tricky because it's so tiny and the reactions so complex. Current methods can't provide enough information or resolution, nor can they capture the reaction dynamics. Now, Argonne's new "near-electrode imager" lets electrochemists zoom right in for a "live," close-up view, to within 2 micrometers of the electrode.

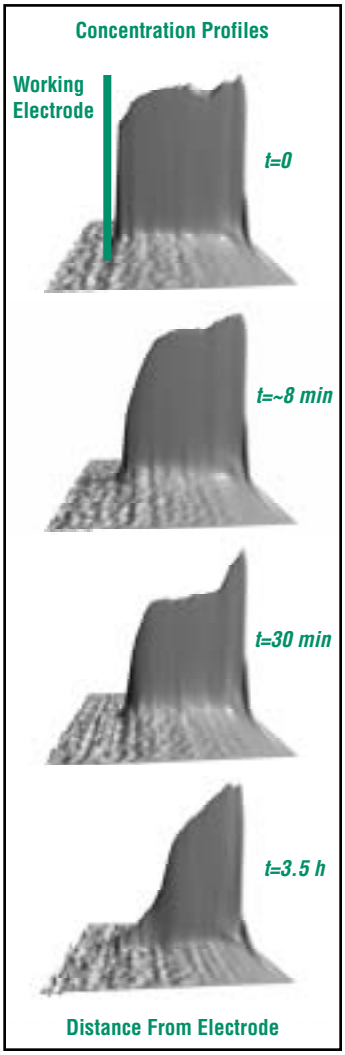
The near-electrode imager combines an electrochemical cell and a nuclear-magnetic-resonance (NMR) chemical analyzer into a single device. The chemical analyzer is based on Argonne's toroid cavity imager, an award-winning invention originally designed for studying industrial catalysis processes at high temperatures and pressures. The new two-in-one instrument has 100 times the visual power of medical magnetic resonance imaging, as well as up to 100 times the analytical sensitivity and 30 times the speed of current NMR imaging. It takes stunningly detailed "snapshots" of electrochemical reactions, simultaneously recording the identities, concentrations, and locations of chemical species without disrupting the reactions.

This unique combination of capabilities can provide fundamental information that may help pinpoint ways to improve the performance of batteries and fuel cells. Researchers hope to increase efficiency by optimizing the role of electroactive ions, improve power by optimizing ion mobility, and lengthen lifetime by learning why electrodes become inactivated by reaction products after many cycles. "We're laying the groundwork for improving the fundamental properties of batteries and fuel cells by providing a clearer understanding of the basic electrochemistry," says chemist Bob Klingler.

An Argonne team is using the imager to study the fundamental chemistry of lithium batteries, particularly lithium-polymer technology, which is the leading contender to power EVs. They want to find a polymer that gives lithium ions the greatest freedom of movement, which should improve the efficiency of charging and discharging and lengthen battery life.

Until now, to determine how the lithium composition changes over distance, researchers had to slice up a used lithium-polymer battery and analyze each sliver in sequence. "Nobody's going to try a lot of different polymers if that's what they have to go through to find out which one is better," says Klingler. "Now we can watch the lithium move in real time, so we can systematically evaluate many polymers in a reasonable time," he says.

The team has focused on creating the device, developing new data collection and analysis methods, and demonstrating its resolution and performance. The next step is to begin screening polymers and additives to enhance performance. *(Info packages 6103 and 7203)*



NMR images show changes in chemical composition of electrolyte over distance and time.

For more information, contact Robert Klingler, phone: 630/252-9960, fax: 630/252-9373, e-mail: klingler@cmt.anl.gov.

ITS Makes Life in the Fast Lane Easier

Intelligent transportation systems combine technologies to improve traffic flow

We've all been there — stuck in traffic and late for an important date! But suppose a little box on the dashboard could tell you when there's trouble ahead and how to get around it? Sound too good to be true? It's not. Intelligent transportation systems (ITS) are being tested and refined on highways and at laboratories nationwide.

Argonne is at the forefront of efforts to make ITS a reality within the next decade. Working with government agencies, universities, and private industry, Argonne researchers bring skills in transportation research, electronics, telecommunications, and high-performance computing to ITS programs.

Each year, traffic congestion contributes to about $100 billion in lost productivity, more than 40,000 lives lost, and more than 5,000,000 injuries. It also adds to the high cost of building and maintaining the nation's roads. ITS may be the answer. By linking drivers, global positioning system satellites, traffic control centers, traffic signals, and "smart vehicles," ITS delivers up-to-the-minute traffic and routing information. According to Argonne's Tom Ewing, "The U.S. Department of Transportation believes that ITS could have an impact comparable to the development of the national highway system."

An Argonne simulator, developed for the GCM Corridor project, shows an example of how ITS could work. A "smart" vehicle's onboard computer receives real-time traffic advisories from a traffic management center, and the in-vehicle navigation system helps the driver find a way to avoid the congestion.

ITS will make traveling safer and more efficient. Less traffic congestion will also mean less fuel burned, lower emissions, and fewer accidents. Onboard computers will give advance warning and help drivers avoid problems on the road. Traffic signals will be coordinated for optimal vehicle flow. Tracking systems will eliminate the need for trucks to stop at weigh stations and will help drivers find the best route. When accidents occur, ITS will help emergency vehicles respond more quickly.

Argonne's work on this innovative use of technology includes the following:

- The ADVANCE Project tested a dynamic guidance system of "mobile navigators" installed in 75 vehicles and linked to a traffic information center. The vehicles were driven within a 300-square-mile area northwest of Chicago for seven months. Argonne managed and evaluated the program, ensuring quality control and seeing that all results were collected and documented.
- The GCM (Gary, Chicago, Milwaukee) Corridor, one of the nation's most heavily traveled areas, has been designated as a testing ground for ITS. The GCM program seeks to rally public support for ITS and develop cooperative relationships among participating organizations. Argonne assists in overall planning, designs ITS components, builds prototypes to test concepts, and analyzes project results. Plans include a communications network, a computer bulletin board, and an integrated travel information system.
- The ITS Simulator Project studies the relationships among various components and models ITS under real-world conditions in the Chicago area.
- With NASA's Jet Propulsion Laboratory and the Chicago Fire Department, Argonne is studying ways to track cross-country hazmat shipments and to respond more quickly when accidents occur.

The U.S. Department of Transportation hopes to deploy ITS nationwide by 2005. With the efforts of Argonne and its research partners, the future is right around the corner. *(Info packages 6501 and 7206)*

**For more information,
contact Adrian Tentner,
phone: 630/252-8454,
fax: 630/252-4500,
e-mail: tentner@ra.anl.gov.**

"Wrapping It Up to Go": Transporting Hazardous and Radioactive Materials Safely

Safety requirements, technical evaluation, and education go a long way in protecting the public and the environment

When you pass a truck displaying hazardous material (hazmat) signs, do you wonder whether it's safe? Does the idea of radioactive materials traveling through your town concern you? Most radioactive and hazardous materials serve necessary industrial, medical, and research purposes; others are by-products of beneficial processes. These materials must be delivered to places where they can be used or disposed of – and safety must come first.

Argonne is helping to ensure that shipments of hazardous and radioactive materials are secure and pose no threat to people or the environment. The Laboratory's expertise encompasses packaging evaluation, risk assessment, emergency response, remote sensing, and logistics and mobility.

The Hazardous and Radioactive Materials Transportation Working Group coordinates Argonne's efforts in this area. Yung Liu, manager, transportation of hazardous materials, sees Argonne's role in practical terms: "Nuclear fuel must be transported to keep reactors going and making electricity. Hazardous waste must be removed and disposed of. But we cannot be lax when it comes to public and environmental safety."

Liu's group ascertains that hazardous and radioactive cargo is packaged for safe transportation. Drawing on experience in materials science, chemistry, mechanical, civil, and nuclear engineering, and quality assurance, this team provides integrated assessments and evaluations – and each member is an expert in applying these disciplines to packaging safety.

The U.S. Department of Energy (DOE) manages radioactive materials under its research, environmental, and defense programs. When shipping these materials, DOE is required by law to use certified shipping containers that meet strict safety standards. The designers of such containers perform extensive tests and analyses under both normal and accident conditions and submit Safety Analysis Reports for Packaging (SARPs) for certification.

Argonne conducts independent technical evaluations of SARPs to determine whether the proposed packaging meets safety requirements and can be certified. The Laboratory is responsible for evaluating about half of the packaging DOE uses in shipping radioactive materials. Argonne's findings are reported to the packaging designer, who then addresses the issues raised and submits a revised SARP for further evaluation. This process is time-consuming, but Liu says, "The regulations are very clear. If the packaging doesn't meet the standards, it doesn't get approved. If it's not certified, nothing gets moved. The pressure on the staff can be intense, but they handle it well."

Argonne also helps prepare DOE packaging review and design guides and technical standards for ANSI, ASME, and ISO. According to Liu, "We participate actively in developing technical standards and guides for hazmat packaging and transportation, and thus have a role in shaping national and international hazmat transportation policy and regulations."

Education is another focus of Argonne's efforts. The Laboratory shares its expertise by providing hands-on training courses for inspectors and others responsible for packaging and transporting radioactive materials. Argonne has also produced ten public information videotapes on hazmat transportation. About 42 million people worldwide have seen these videos on television.

Future *TransForum* articles will highlight other aspects of Argonne's hazardous and radioactive materials transportation research.

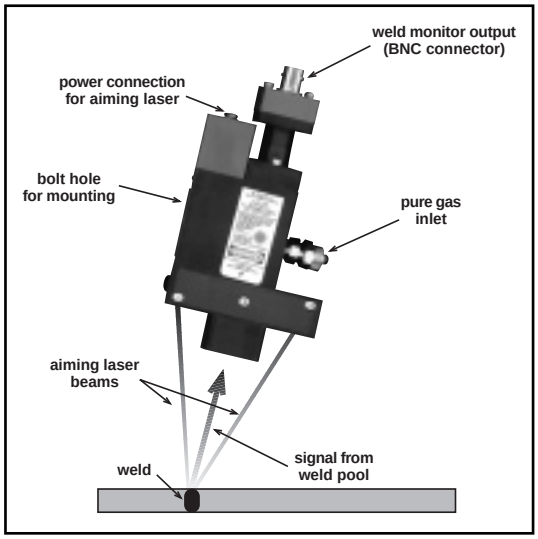
For more information,
contact Yung Liu,
phone: 630/252-5127,
fax: 630/252-3250,
e-mail: yung_liu@qmgate.anl.gov,
Web: http://www.ead.anl.gov/~hrmt/

Containers like this one, used for dangerous goods, undergo meticulous safety testing before they can be certified for use.

On-Line Monitor Ensures Strong Laser-Beam Welds

Low-cost sensor checks welds in process and reduces waste

Auto manufacturers need to ensure the integrity of the laser-beam welds that join steel parts. Especially in safety-related applications, such as the sealing of components in air bag canisters, every weld is critical. Until recently, however, no effective, reliable instrument for real-time monitoring of weld penetration was available.



Argonne, working with industrial partners, has developed a system to monitor laser welding operations as they occur. The monitor is easy to operate in a harsh environment and can be used for a wide range of metals, including steel, aluminum, and magnesium. Its cost — about $15,000 — is considerably less than the $50,000 price tag of an existing monitoring system, which cannot measure weld penetration on-line.

The monitor's unique engineering design uses a passive sensor and related optics to measure infrared emissions from the weld during processing. The monitor can give a worker on the factory floor information about the weld's penetration depth and surface quality. Welds must be shallow enough so that heat or spattered material does not damage the part, yet deep enough to form strong bonds. Undercut or poor surface quality may decrease weld strength. The monitor flags bad welds and can automatically signal the system to change weld parameters or laser power levels.

Because the monitor senses the integrity of the weld remotely, destructive weld evaluation can be used less frequently. Thus, not only is the quality of parts improved, but the scrap rate is decreased.

The weld monitor has been successfully tested in the laboratory and in an industrial setting. A U.S. patent was granted in 1997, and a commercial version is available. Other uses for the monitor are also being explored — it may be applicable to laser-beam heat-treating of gears and other components, laser-beam cladding for repairing components, and arc welding.

Spawr Industries, Inc. (Lake Havasu City, Arizona) has integrated the monitor into a focusing optics assembly. This design is ideal for use in factories, where space for a stand-alone unit may be limited. Integration ensures that the device is aimed correctly, so no adjustments are needed, and the monitor can easily be used on the factory floor.

Spawr, which specializes in developing high-power laser beam delivery modules and optics, has licensed the technology and manufactures two versions of the unit. The integrated unit, which is appropriate for industrial applications, can be retrofitted on existing laser welding systems. The stand-alone unit, which uses a diode laser for aiming and a gas purge for spatter protection, is suitable for research and development applications.

The monitor is based on laser welding research performed under agreements with Delphi Energy & Engine Systems and the Low-Emissions Partnership (Chrysler, Ford, and General Motors).

**For more information,
contact Keng Leong,
Argonne National Laboratory,
phone: 630/252-3254,
fax: 630/252-4007,
e-mail: keng_leong@qmgate.anl.gov,
or Walter Spawr, Spawr Industries,
phone: 520/453-8800,
fax: 520/453-8811,
e-mail: spawr@ctaz.com.**

**To request info packages,
(numbers are given at
the end of each article),
contact:**

***Industrial Technology
Development Center***
**Argonne National Laboratory
9700 South Cass Avenue, Bldg. 201
Argonne, IL 60439
phone: 800/627-2596
fax: 630/252-5230
Web: http://www.itd.anl.gov**

LOOKING DOWN THE ROAD

Last quarter, we published the first issue of *TransForum*. Not only have people written and called to compliment the quality of our publication (my thanks go to Argonne's Information and Publishing Division), but we have received numerous inquiries for further information on our technologies. Keep those cards and letters coming.

In this issue, we highlight two collaborations with the U.S.auto industry. Our unique Advanced Powertrain Test Facility will provide the U.S. Department of Energy with an unbiased evaluation of various hybrid electric vehicle designs. In addition, U.S. auto companies indicate that they see the facility helping them as well as the suppliers that develop components (engines, motors, energy storage devices, etc.). Argonne has also developed a "near-electrode imager" that is being used to improve the performance of battery and fuel cell electrodes that could help the Partnership for a New Generation of Vehicles meet its goals.

In the manufacturing area, Argonne's research with laser welding has also attracted the interest of U.S. automakers and their suppliers. One of our success stories, if success is measured by commercialization of our technologies, is a real-time laser weld monitor. This innovation has been licensed to Spawr Industries and integrated into their focusing optics assembly. Argonne's weld monitor was based on laser research conducted in partnership with Chrysler, Ford, General Motors, and Delphi Energy and Engine Systems. The monitor also won a Federal Laboratory Consortium award for technology transfer.

Two other research areas are covered in this issue. Argonne works closely with the State of Illinois and the Gary-Chicago-Milwaukee Priority Corridor to advance the state of development of intelligent transportation systems. We also have an extensive research program in hazardous and radioactive materials transportation; this issue highlights one aspect of that work.

Larry R. Johnson
Director

FASTRAX

An economical, energy-efficient process for producing ethyl lactate, developed by ***Rathin Datta, James Frank, Shih-Perng Tsai, Michael Henry, Tony Fracaro, Paula Moon,*** and ***Yuval Halpern,*** has been named a finalist in the 1998 Discover Magazine Awards for Technological Innovation. The nontoxic, biodegradable solvent can be produced at half the current cost, which makes it an attractive alternative to the halogenated and toxic solvents now used for industrial cleaning, degreasing, and paint formulation.

Another finalist in the 1998 Discover Magazine Awards for Technological Innovation is the near-frictionless carbon films developed by ***Ali Erdemir***. These coatings can be deposited on any substrate and are exceptionally wear-resistant and durable on steel, ceramics, and plastics. Argonne will work with Diesel Technology, Front Edge Technology, and Stirling Thermal Motors to further develop these coatings for use in motor vehicles. (See related story in *TransForum*, Vol. 1, No. 1.)

Ali Erdemir, Cuma Bindal, and ***George Fenske*** (Argonne) and ***Paul Wilbur*** (Colorado University) have been awarded the Edmond E. Bisson Award by the Society of Tribologists and Lubrication Engineers for the paper, "Tribological Properties of Hard Carbon Films on Zirconia Ceramics," which appeared in *Tribology Transactions*, Vol. 39, No. 3, pp. 735-744.

Keng Leong (Argonne) and ***Walter Spawr*** (Spawr Industries) have received a Federal Laboratory Consortium for Technology Award for their work on a new laser weld monitor (see related story on page 6). These awards recognize employees who have done an outstanding job of transferring technology developed in a laboratory to outside partners, primarily in the private sector.

Larry Johnson has been appointed to the Advisory Committee for Lawrence Livermore National Laboratory's Energy, Manufacturing, and Transportation Program. The committee provides an external review of the program's technical strength and relevance and the overall quality of the technical work.

S.Y. Chen has been elected chairman of the technical committee of the Transportation Risk Assessment Working Group (TRAWG) for DOE's National Transportation Program. The TRAWG coordinates DOE efforts related to the National Environmental Policy Act, identifies and resolves issues regarding streamlined risk analysis, facilitates standardization, and provides guidance and oversight.

Frank Stodolsky has been selected to chair the Advanced Powerplant Committee by the Society of Automotive Engineers. During his two-year term, Stodolsky will also serve on SAE's Powerplant Governing Board.

PARTNERING WITH ARGONNE

Argonne is seeking industrial partners to develop advanced transportation technologies. The following types of working arrangements can be made:

- In a *reimbursable R&D 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 *cost-shared R&D agreement*, 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 other 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:

Industrial Technology Development Center
Argonne National Laboratory, Bldg. 201
9700 South Cass Avenue, Argonne, IL 60439
phone: 800/627-2596
fax: 630/252-5230
Web: http://www.itd.anl.gov

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Contributors: Jane Andrew, John DePue, Mary Fitzpatrick, Marita Moniger, Renée Nault, and Betty Waterman

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Betty Waterman
TransForum
Argonne National Laboratory
9700 South Cass Avenue, Bldg. 362
Argonne, IL 60439
Phone: 630/252-9765
Fax: 630/252-1393
e-mail: bwaterman@anl.gov

ARGONNE NATIONAL LABORATORY
TRANSPORTATION TECHNOLOGY R&D CENTER

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