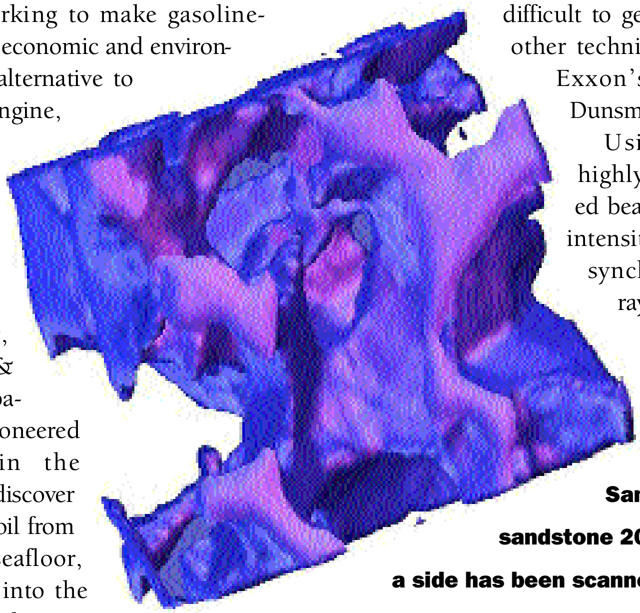
Gas and Gasoline

Exxon Corp. envisions a rich future for gasoline in helping power motor vehicles in the next century, albeit in a way quite different from today. Exxon scientists and engineers are working to make gasoline-based fuel cells an economic and environmentally friendly alternative to the combustion engine, improve refining technology, and develop new ways to identify petroleum deposits.

Ever since 1919, Exxon Research & Engineering Company (ER&E) has pioneered improvements in the processes used to discover and extract crude oil from the ground and seafloor, and to convert it into the gasoline, diesel oil, kerosene, and other fuels that consumers need.

Understanding the type of rock and the formations in which oil is trapped is a key component in extracting oil efficiently. Sandstone, a common medium for natural underground oil storage, is a porous material, and a large volume of oil, brine, and gas can lie within its pores. However, scientists do not have a good model of sandstone pore connectivity, which they need to understand how fluids will percolate through the rock as oil is extracted.

Scientists at Exxon Corporate Research are studying the three-dimensional connectivity of the network of pores found in sandstone with the aid of X-ray microtomography. The technique, pioneered at Exxon Corporate Research, is similar to a medical CAT scan and yields a three-dimensional image with a resolution typical of an optical microscope. "This is the only practical way to measure the connectivity of pores, which is very difficult to get with any other technique," says Exxon's John H. Dunsmuir.



Sample of sandstone 200 µm on a side has been scanned and rendered to make the sand grains invisible but highlight the pore body network in order to elucidate oil paths.

Using the highly collimated beam of high-intensity, tunable synchrotron X-rays from the National Synchrotron Light Source, located at Brookhaven National Laboratory, a 1-cm^3 rock specimen can be scanned nondestructively to produce a three-dimensional image.

Researchers gather data with a charge-coupled device over 1 hour and then reconstruct this information as a cube of 1,024 pixels on each side, which requires another hour. "We can examine that three-dimensional image to measure the topology, which is really what we're after, and to some extent, the composition as well," Dunsmuir says. "This allows us to clearly model the properties of porosity and permeability."

Such modeling can help scientists devise new methods of interpreting the readings of sensors lowered down drill holes and provide a clearer picture of the local environment and fluid flow of individual wells.

On the refining side, Exxon scientists are using microtomography to understand how catalytic metals—platinum, for example—deposited on pellets rearrange themselves during the fluid catalytic-cracking process. Unevenly distributed metals reduce the efficiency of the refining operation. By taking a three-dimensional image at energies above and below an absorption edge (the energy at which a photon can remove a shell electron), the elemental distribution of the metal on a pellet can be determined. The technique is providing insights into ways to maintain metal distributions more evenly and thus lengthen the operational lifetime of the catalysts and make the use of expensive platinum more efficient.

Fossil fuels have powered much of the world's industrialization. However, their potential effects on local air quality and global climate have raised concerns worldwide and prompted research collaboration between energy and automotive companies to develop new fuel and engine systems to reduce the environmental impact of transportation. One promising power source, the fuel cell (see *The Industrial Physicist*, 2/99, pp. 15-17), combines hydrogen and oxygen

ER&E, which has been a member of the American Institute of Physics Corporate Associates for 20 years, will host the Industrial Physics Forum for Corporate and Academic Leaders on Oct. 25-26 in Annandale, New Jersey. The meeting is sponsored by the AIP Corporate Associates, *The Industrial Physicist*, and the American Physical Society's Forum on Industrial and Applied Physics.

The conference theme this year is "Technological Innovations for Energy in a World Without Walls." Sessions will feature talks on markets and technology, resource exploration, science and technological innovation in energy, ultrahigh-strength steel for gas pipelines, and physics at the interface with chemical engineering. Attendees will also have the opportunity to tour the Exxon Corporate Research facilities.

A policy session titled "Environmental Drivers and Energy Technology" will include talks on resources and the environment, carbon dioxide management technology, and innovation in ground-transportation power plants. The annual "Frontiers of Physics" sessions will feature four talks about new physics research: chemical physics of protein folding, quantum-cascade lasers, the accelerating universe, and self-assembling systems.

Industrial Physics Forum for Corporate and Academic Leaders in a low-temperature electrochemical process that efficiently and cleanly produces electricity and water.

Hydrogen for the fuel cells could come from an on-board hydrogen tank or from high-density liquid hydrocarbon or alcohol fuels that are converted to hydrogen by a device, called a reformer, carried aboard the vehicle. One appeal of using liquid hydrocarbons to power fuel-cell vehicles is that a vast infrastructure for its distribution is already present worldwide. It would take a long time and huge investments to develop a comparable distribution system suitable for hydrogen.

Currently, most hydrogen gas is made by reacting natural gas in large reformers up to five stories tall. Exxon and General Motors researchers are working together in an attempt to reduce the scale of the reformer to a device that will make hydrogen on demand for powering a fuel-cell car or truck. The reformer and fuel cell must provide the performance and response of today's combustion engines. "Drivers are used to a car that starts in an instant, gives good acceleration, and has a long range before needing refueling," says John Robbins, a scientist at Exxon Corporate Research. Prototype fuel-reformer/fuel-cell systems for vehicles are expected within the next 2 years.

Such fuel-cell vehicles will not be emission-free. Carbon dioxide is an inevitable byproduct of hydrogen production from fossil fuels, which is by far the least expensive way to generate this fuel. However, the target of doubling fuel economy would reduce CO_2 emissions to 50% of those of today's cars. Fuel-cell vehicles are also expected to offer step-change reductions in vehicle tailpipe emissions that affect low air quality.

For more information about the AIP Corporate Associates, to get an application form, or to learn about the Industrial Physics Forum for Corporate and Academic Leaders, please visit our Web site, www.aip.org/aip/corporate, e-mail us at assoc@aip.org, or call 301-209-3135.