Fighting Fire with Foam

New insulating technology advances fire protection.

Containment is the name of the game in fire protection. The longer a structure can withstand flames and prevent fire from spreading, the greater the chances that lives and property will be saved.

Researchers at the Georgia Institute of Technology have developed a new insulating and fire protection technology: a closed-cell foam composite that expands when exposed to fire.

This insulation can withstand fire up to 100 times longer than existing products, reports Juan Vitali, a principal research engineer in Georgia Tech Research Institute's Electro-Optics, Environment and Materials Laboratory, who leads the research team along with Professor Haskell Beckham from the School of Polymer, Textile and Fiber Engineering.

Insulating foam can be structured with either open or closed cells. In closed-cell foams, a plastic membrane surrounds each cell, preventing gas or air from passing through it.

Georgia Tech's technology combines closed-cell foam with special pyrolyzing polymers that break down and then swell when exposed to fire. The unique composition of the foam composite results in an insulating material that is lightweight, flame-resistant and extremely durable.

In collaboration with RBX Corp., the Georgia Tech team will adapt this technology to produce fire-resistant aircraft shelters for overseas military deployments, a project funded by the U.S. Air Force Research Laboratory. (Fire is a major cause of peacetime casualties because of the large amount of ignitable fuel stored in aircraft shelters.)

For these military shelters, the researchers plan to create a two-level protection: When the foam is first exposed to fire, one group of polymers will break down and release fire-suppressing gases. If these gases don't extinguish the fire, then another group of special materials will activate at higher temperatures and expand, which will increase the volume of air between the fire and the tent. The expansion of these materials also creates a charring to provide additional insulation.

Beyond military shelters, this technology has many other applications:

- *Interior coating for aircraft engine bays*. In case of an engine fire, the foam will expand and extinguish the blaze.
- *Thin lining for firefighters' suits.* Vitali is working with the U.S. Department of Energy's Oak Ridge National Laboratory and North Carolina State University to develop a new protective suit for first responders. "Many firefighters involved in the Sept. 11 terrorist attacks complained of exhaustion because their garments were so heavy," says Vitali, who hopes to cut the weight of suits in half while increasing the level of fire protection.
- *Insulation for commercial buildings.* Currently, fireproofing paints with intumescent polymers are sprayed on building as insulation. But these paints offer limited protection because they break down quickly when exposed to fire.

If his fireproofing-foam concept had been used in the World Trade Center buildings, Vitali believes more lives could have been saved. "The beams of the buildings would still have ultimately buckled and collapsed, but the foam would have delayed the temperature rise and bought more time, perhaps hours," Vitali says. "And during fire, every second counts. Anything you can do to slow down the expansion of the fireball translates into lives saved."

The researchers are now working on a manufacturing process, developing a set of intumescent polymers and additives that will match the foam's curing process.

"It's an optimization process," Vitali explains. "We're looking for structures that will give us the right activation temperature."

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GTRI researchers have developed a new insulating and fire protection technology that can withstand fire up to 100 times longer than existing products.

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Nuclear Energy for Generation IV

Pebble-bed reactor technology considered safer and more efficient than previous designs.

Georgia Institute of Technology researchers are helping develop novel methods for a new generation of advanced nuclear power reactors intended to be safer and more efficient than current designs.

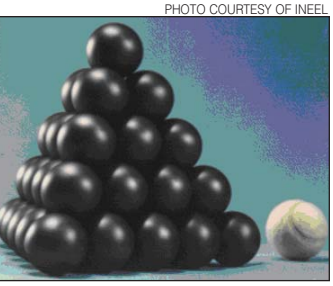
Called modular pebble-bed reactors (PBMRs), the gas-cooled design is considered inherently safe – it prevents an accidental radiation release — for several reasons. Among them are its use of coated particles in the fuel element, helium as a coolant and graphite as a moderator. Other factors are its low-power density, high-thermal inertia of the reactor core and the use of a continuous fueling scheme.

The pebble-bed modular reactors approach is one of several designs being investigated by the Idaho National Engineering and Environmental Laboratory (INEEL) for the U.S. Department of

PHOTO © GETTY IMAGES INC., 2003

Nuclear reactors produce intense heat when they force neutrons to strike uranium atoms, causing them to split or "fission" in a continuous chain reaction. In the predominant light-water reactor design, water cools the nuclear fuel, and the resulting steam powers an electric generator.

PHOTO COURTESY OF INEEL



In pebble-bed modular reactors, a cylindrical vat is filled with billiard-ball-sized "pebbles" packed with graphite that contains thousands of uranium specks called "microspheres."

Energy. The department is leading the development of the next generation of nuclear technology called Generation IV reactors.

"There are many mechanisms in water-cooled, light-water reactors that will stop an accident from occurring," says Farzad Rahnema, a professor in the Nuclear and Radiological Engineering Program of the Woodruff School of Mechanical Engineering and Georgia Tech's principal investigator on two INEEL-funded, reactor-related projects. "But in the pebble-bed reactors, you don't even need that extra degree of safety."

In one study, Rahnema and his colleagues are assisting INEEL on a Nuclear Energy Research Initiative (NERI) project for the Department of Energy. Researchers are developing advanced methods for PBMR design, analysis and fuel-cycle optimization.

Assisted by INEEL and a Pennsylvania State University researcher, Georgia Tech is leading a second NERI project. Basing their study on neutron transport theory, researchers are developing an innovative method for efficient design, analysis and monitoring of advanced Generation IV light-water reactors and the PBMR. Researchers expect to complete both projects by September 2005.

Nuclear reactors produce intense heat when they force neutrons to strike uranium atoms, causing them to split or "fission" in a continuous chain reaction. In the predominant light-water reactor design, water cools the nuclear fuel, and the resulting steam powers an electric generator.

By contrast, helium gas cools a pebble-bed reactor. In the PBMR, a cylindrical vat is filled with billiard-ball-sized "pebbles" packed with graphite that contains thousands of uranium specks called "microspheres." Heat from the microspheres passes through the graphite and into the helium. Heated helium is channeled into a gas turbine to generate electricity.

Running the high-temperature gas coolant through advanced gas turbines makes the PBMR more efficient than current and advanced generation reactors, explains Abderrafi Ougouag, the INEEL principal investigator on the project. Such thermal efficiency yields more electricity produced by each split atom. Also, terrorists would find it difficult, if not impossible, to use fuel pebbles for making nuclear weapons, he adds.

Perhaps the greatest appeal of gas-cooled reactors such as PBMRs is their safety. "If you deliberately tried to cause an accident, nothing would happen," Ougouag says. "You could walk away, and the reactor would safely shut itself down naturally."

That's because pebble-bed reactors use "low-enriched fuel" – uranium in which only about 8 percent is the easily fissioned isotope Uranium-235. The rest is Uranium-238, which usually absorbs neutrons without undergoing fission. When the reactor temperature rises, the propensity of Uranium-238 to absorb neutrons increases. The Uranium-238 steals neutrons from Uranium-235, and the reactor shuts down automatically.

A PBMR power plant is attractive for its economically competitive nuclear power output on a comparatively small scale — about 100 megawatts of electricity instead of the 1,000 megawatts of a typical light-water reactor, explains William Terry, another INEEL investigator. PBMRs would fit the energy needs of rural locations and developing countries better than large and complex light-water units, he adds.

A South African company, PBMR (Pty.) Ltd., is leading the commercial development of pebble-bed reactor technology. It plans to sell its design internationally. For now, the only functioning PBMR reactor is a small, 10-megawatt test facility in the People's Republic of China.

Current PBMR designs are based on a German approach developed more than 20 years ago. The United States wants to develop its own pebble-bed reactor design based on a more up-to-date approach.

Georgia Tech contributes to that effort in the INEEL-led project as Rahnema's team helps develop a neutronics analysis tool to calculate the most effective configurations for directing the energy-producing fission process.

Farzad Rahnema, right, is leading a research team, including Ph.D. student Scott Mosher, that is developing novel methods for a new generation of advanced nuclear power reactors intended to be safer and more efficient than current designs.

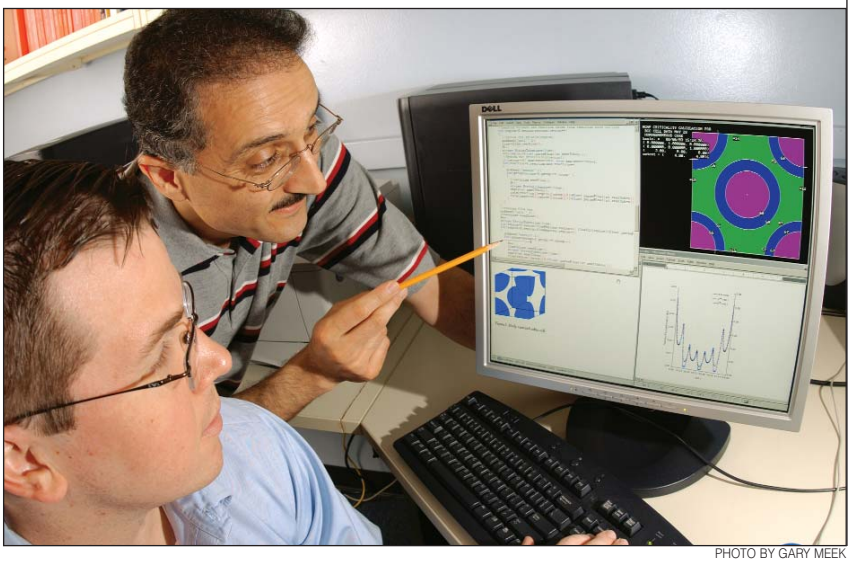


PHOTO BY GARY MEEK

Meanwhile, in the project led by Georgia Tech, researchers are developing a more accurate and efficient method for determining neutron distribution — required for calculating the depletion of and the power generated by the fuel in pebble-bed and other reactors.

— Rick Robinson, freelance writer

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The Need for Speed

GTRI creates ergonomically superior interface for international manufacturer.

Today's competitive manufacturing environment requires the highest levels of efficiency. And though sophisticated automation can give manufacturers an edge, that equipment is only as effective as the humans operating it.

Jeffrey M. Gerth, a senior research scientist at the Georgia Tech Research Institute (GTRI), has been working with DEK, an international machine manufacturer headquartered in Weymouth, England. Gerth's mission: to improve the user interface on screen printers that DEK produces for the circuit-board and electronics-assembly industries worldwide.

User interfaces – the commands or menus that allow people to communicate with a computer or electronic device – are critical to nimble manufacturing. "The job of operators is to monitor machines so they're in constant operation," says Gerth, who specializes in human factors at GTRI's Electronic Systems Laboratory. "If production stops or isn't going as fast as intended, then a manufacturer is losing money."

DEK approached Gerth in 2001 after seeing a project from Georgia Tech's Manufacturing Research Center demonstrated at a trade show. The project included an Internet portal and user interface that Gerth had designed for surface-mount technology (SMT) manufacturing – one of DEK's domains.

Now in its final stages, Gerth's redesigned interface saves time and streamlines production. Some of its advantages include:

- *Easier to use.* Whereas DEK's former interface was text-based, the new interface uses graphics to reduce dependency on language, which is important for an international player like DEK. What's more, the new interface accommodates a number of functional adjustments made to screen printers over the years – customer requests that didn't take machine operators into account until now.
- *Decreases training time.* Training materials are embedded in the interface, saving operators from having to reach for a manual whenever they have a question.
- *Reduces errors.* The new interface is geared to support best practices and circumvent problems. For example, a new alert system tells operators when replenishments, such as cleaning solvents, are dropping too low. The interface not only reports errors, but also provides troubleshooting tips to help operators take appropriate action instead of calling on a process engineer.

In fact, the new interface is so user friendly, DEK has dubbed it the "Instinctiv™." A beta version of Instinctiv debuted this spring at the APEX manufacturing show in Anaheim, Calif., and is now being tested in two of DEK's critical markets.

"The project has been a great success," says Dick Johnson, DEK's software manager. "DEK Instinctiv is a new and easier way of interacting with DEK printers. It's an interface designed for machine operators — not just engineers."

Creating a user-friendly interface is no easy undertaking. "For one thing, users don't always know what they need," Gerth says.

Before Gerth even began the actual redesign, he toured factories using DEK machines in the Czech Republic, Mexico, the United Kingdom and the United States to observe machine operators and ask them to critique the existing interface —

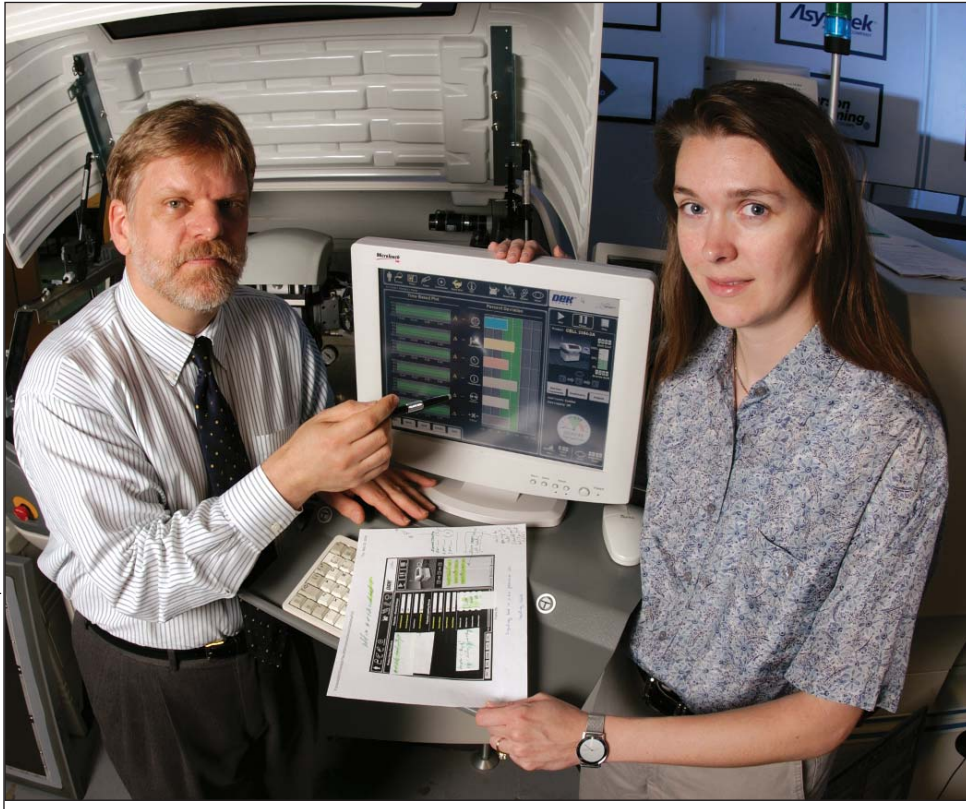

PHOTO BY GARY MEEK

Jeffrey M. Gerth, left, a GTRI senior research scientist, has been working with international machine manufacturer DEK to improve the user interface on screen printers the company produces for the circuit-board and electronics-assembly industries worldwide. Michelle Berryman, a former graduate student and researcher, assisted Gerth with this project.

what features they liked, disliked and used most often. He also interviewed technicians and line managers who were responsible for maintaining the machines.

One of Gerth's goals was to expand the role of machine operators, making them more capable of maintaining screen printers during production and less dependent on process engineers.

This led to a "task-based" approach, which was key to the troubleshooting component. Instead of overwhelming operators with too much information at once, only information needed for the task at hand is presented to them. Graphics are also used as often as possible to help operators identify problems and suggest specific solutions.

Troubleshooting is especially difficult because of its non-linear nature. "You don't necessarily have a single root cause for a given problem, but rather, a number of possible causes could exist," Gerth says. "We attempted to establish all possible root causes for the most frequently encountered problems and then gave 'hints' to their most probable causes."

Creating easily understood icons was another challenge. Besides legibility issues, culture plays a role in machine operators' comprehension. For example, a checkmark typically conveys that a task has been completed; however, in some cultures, a checkmark means something remains to be done.

Aiding Gerth in the interface project is Michelle Berryman, a recent graduate student from Georgia Tech's College of Architecture's Industrial Design Program.

The collaboration between engineering psychology and industrial design has been a unique and important one, Gerth says: "Industrial designers are particularly good at 3-D modeling and graphic design. The mockup concepts we can jointly create allow the end-user evaluation to be done on a more complete and realistic prototype."

Gerth is currently working with Lorraine Justice, director of the Industrial Design Program, to create a laboratory for collaborative teaching and research for engineering psychology and industrial design. "Our world is becoming much more laden with complex electronic devices – and they all have user interfaces," Gerth says. "We need interfaces that are easier to understand. Design will continue to be our biggest advantage."

— T.J. Becker

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Instead of overwhelming operators with too much information at once, only information needed for the task at hand is presented to them.

Move to Midtown

Technology Square extends Georgia Tech's campus into the Midtown Atlanta corridor.

This summer marked the migration of several Georgia Tech groups to Technology Square, the institute's new $256 million, multi-building complex in Midtown Atlanta. First announced in June 2000, Technology Square provides state-of-the-art facilities and brings together a unique combination of education, research and economic-development activities that will help Georgia Tech expand its outreach.

Among units relocating to Midtown:

- DuPree College of Management moved into 189,000 square feet at 800 West Peachtree St., bordered by Spring, Fifth and Armstead streets.

PHOTO BY GARY MEEK

The Tech Trolley transports students, faculty and visitors between Technology Square in Midtown Atlanta and the main Georgia Tech campus just across the Fifth Street Bridge.

PHOTO BY GARY MEEK

The Economic Development Institute is devoted to growing Georgia's economy through technology-driven solutions. EDI occupies about 21,000 square feet at 760 Spring St.

- The Global Learning Center, Georgia Tech's professional and continuing education center, now occupies 113,000 square feet at the corner of Fifth and Williams streets.
- The Economic Development Institute is devoted to growing Georgia's economy through technology-driven solutions. EDI occupies about 21,000 square feet at 760 Spring St.
- The Advanced Technology Development Center (ATDC), Georgia Tech's incubator that helps entrepreneurs launch and build technology companies, has relocated its headquarters to 122,500 square feet at 75 Fifth St.
- Georgia Tech VentureLab, a one-stop center that helps Georgia Tech faculty members commercialize their technology, is also located at 75 Fifth St.
- The Center for Quality Growth and Regional Development, a research center that focuses on smart growth and sustainability issues, is located at 760 Spring St. in the same building as EDI.
- The GVU Center, which advances the interaction of people, computers and information, is moving into about 35,000 square feet at the Technology Square Research Building located at 85 Fifth St.
- The Georgia Tech Bookstore, managed by Barnes & Noble, is located in 50,000 square feet on the southeast corner of Fifth and Spring streets.

Being at Technology Square will increase collaboration for many of these units and help advance their respective missions.

"The real news is not about bricks and mortar – it's about heart and soul," says Terry Blum, dean of the DuPree College of Management. "The new building is our laboratory for preparing business leaders for changing technological environments. We'll join with our Georgia Tech colleagues in interdisciplinary activities to make the whole greater than the sums of its parts. And we'll develop stronger ties with the Atlanta business community through the Huang Executive Education Center." Housed in a self-contained wing, the new Huang center is devoted to corporate conferences, retreats, meetings and training events.

For EDI, benefits of the relocation include increased visibility and easier access. One of Georgia Tech's most active outreach groups, EDI provides a variety of services to stimulate business and industry — from attracting new companies to helping existing ones expand and become more

PHOTO BY GARY MEEK

Technology Square provides state-of-the-art facilities and brings together a unique combination of education, research and economic-development activities to help Georgia Tech expand its outreach. The DuPree College of Management and the Barnes & Noble Bookstore at Georgia Tech draw students to the complex.

PHOTO BY GARY MEEK

Students frequent the Technology Square complex to attend classes.

competitive. Yet EDI's former headquarters in the O'Keefe Building made interaction with the business community difficult.

At O'Keefe, EDI only had a couple of visitors per day, says Rick Duke, EDI's director. But at Technology Square where EDI is next door to the new Georgia Tech Hotel and Conference Center, it's easy for guests to drop by EDI offices, and Duke hopes to have 100 visitors a day.

Taking advantage of its new accessibility, EDI is dedicating 2,000 square feet on its ground floor to an "Innovations Gallery." Open to the public, this new exhibition area will feature art, kinetic and static displays that illustrate EDI's influence on companies and communities throughout Georgia.

For ATDC, the relocation provides space that's more conducive to its networking and educational activities, such as its new 600-square-foot boardroom and 2,700-square-foot learning center.

In addition to more modern facilities, the incubator's new space gives its members greater opportunities for learning from each other. Instead of being spread out on six floors in two buildings at ATDC's former headquarters, entrepreneurs now are located primarily on one floor of a single building at Technology Square.

On its third floor, ATDC has dedicated 50,000 square feet to the new Georgia Tech Venture Center (GTVC), which houses individuals and groups that can benefit ATDC members or engage in collaborative research with Georgia Tech. Examples are:

- industry groups, such as the Technology Association of Georgia (TAG);
- attorneys, accountants, investors and other service providers who focus on technology entrepreneurs;
- "landing parties" formed by established companies either setting up shop in Georgia for the first time or spinning off new divisions.

The idea behind GTVC is to expand interaction. "We've had some support companies around before, but this allows us to take it to another level," says Wayne Hodges, vice provost for Economic Development and Technology Ventures.

— T.J. Becker

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On Paper

Institute of Paper Science and Technology integrates with Georgia Tech.

The forest products industry, one of Georgia's largest economic drivers, will benefit from a recently integrated pulp and papermaking research program at the Georgia Institute of Technology, officials say.

In July 2003, the Atlanta-based Institute of Paper Science and Technology (IPST) became one of four major research institutes at Georgia Tech. Now, broader-based studies are integrating IPST's traditional research focus on papermaking and related processes with Georgia Tech's expertise in science – including paper science — engineering and computing, says Charles Liotta, vice provost for research and professor in the Schools of Chemistry & Biochemistry and Chemical & Biomolecular Engineering.

"Thus, the researchers at IPST will have more interaction with high-tech subjects, such as bioengineering, chemical engineering, computing and so on," Liotta says. "The arrangement will help influence the research direction as the industry faces the challenges of the 21st century."

W. James (Jim) Frederick Jr., the new director of IPST, expects this new research to foster economic development in Georgia, a key aspect of Georgia Tech's mission, he says.

IPST has conducted research on the most common problems facing the pulp and paper industry. Those issues include the high cost of

PHOTO BY PHILLIP SPEARS

Right: IPST researcher Yulin Deng has designed an apparatus for surfactant spray technologies for flotation de-inking. De-inking is an important part of the recycling process for paper.

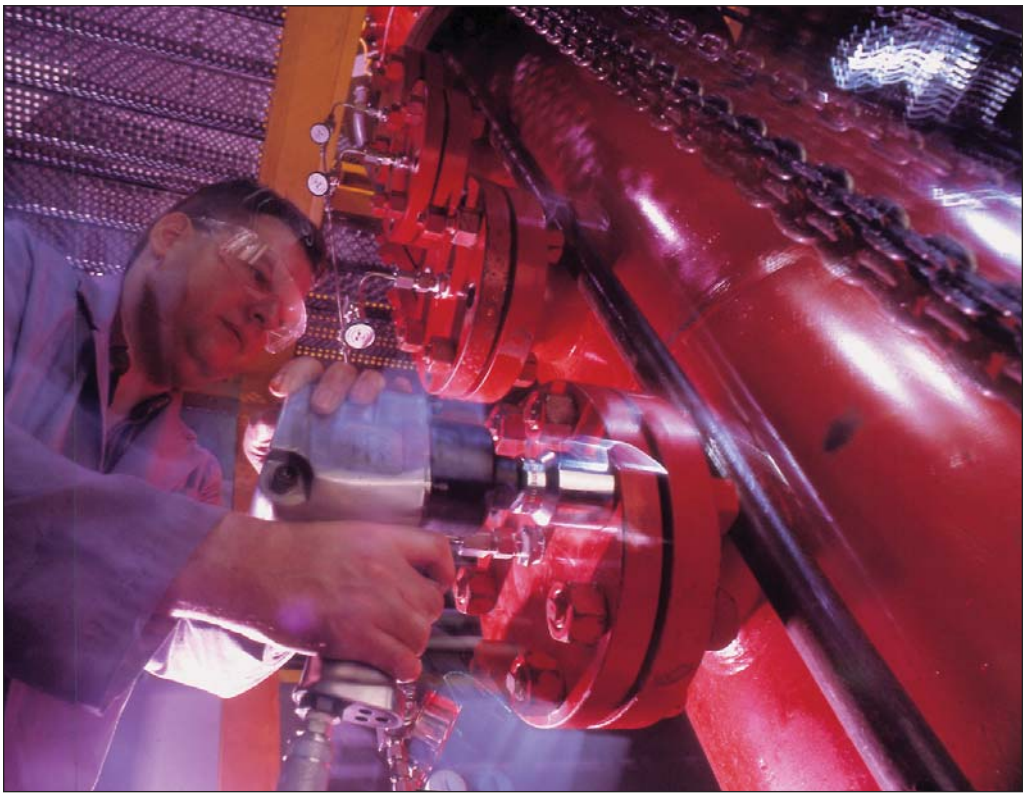

PHOTO BY PHILLIP SPEARS

PHOTO BY PHILLIP SPEARS

Above: The Institute of Paper Science and Technology has conducted research on the most common problems facing the pulp and paper industry, including the high cost of paper production, recovery of paper-making chemicals, tree growth and paper recycling.

Left: IPST researcher Scott Sinquefield is studying the gasification of black liquor for chemical recovery and increased energy production.

paper production, recovery of papermaking chemicals, tree growth and paper recycling. Under the Georgia Tech umbrella, the research focus will expand to include more visionary, long-term problems, explains David Bell, director of institute development and assessment at IPST.

For example, the development of alternative uses of paper is one area of interest to both scientists and industry leaders. Outgoing IPST president Jim Ferris refers to these as intelligent papers, or "papers that do stuff." He envisions a day when paper could be embedded with microelectronic circuitry that could revolutionize the way paper is used.

Another exciting area of potential research involves the application of thin-film chemistries to paper, creating chemical magnets for cleaning air streams, Bell notes. Such novel efforts would involve collaboration among a team of experts and could ultimately benefit the industry and society by providing new uses and markets for paper.

Georgia Tech is also expanding biological research on commercially valuable species of trees. By pursuing opportunities in biotechnology, researchers can find ways to improve growth rates of trees and the quality of the wood they produce, making U.S. and Georgia forests more competitive in the global marketplace, Bell explains.

Such research exemplifies the opportunities available with the integration of IPST and Georgia Tech. "Research that cuts across disciplines will be the norm," Bell adds.

The integration of the two organizations is also expected to boost Georgia Tech's undergraduate education program that awards a certificate in pulp and paper engineering. Professor Jeff Hsieh administers this program.

— Patricia J. West, freelance writer

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PHOTO BY PHILLIP SPEARS