IRON WORKS!

INNOVATIVE TECHNOLOGY TO CLEAN WATER
As we compile this Fall 2009 issue of the PITA Newsletter, the Pennsylvania General Assembly and Governor Rendell continue to work towards an agreement on the 2009-2010 budget for the Commonwealth. We remain optimistic for continued funding of PITA with an expected budget that is consistent with overall budget reductions in Pennsylvania as a result of the global economic downturn. Such continued funding of PITA demonstrates Pennsylvania’s commitment to long-term technology based economic growth, with programs such as PITA leading the way.

This issue of the Newsletter features examples of programs where collaboration between university research teams and industry partners is solving real-world problems and producing technology for economic growth.

In this issue, we highlight Lehigh University research that is developing the use of scrap iron as a cheap and effective method of cleaning up contaminated water. The Lehigh researchers have partnered on this project with Lehigh Nanotech LLC, a knowledge-driven firm in Bethlehem, PA, focused on the development of value-added nano-materials for environmental remediation and wastewater treatment.

Lehigh researchers have also been working on PITA-funded projects with electrical companies to improve production and efficiency. A highlighted project features Lehigh partnering with PPL Corporation to develop design and fabrication methods for improving the welding of different kinds of steel pipes in power plants, with the goal of prolonging power plant life.

Researchers at ICES are collaborating with Pittsburgh-area medical schools and facilities to enhance the capabilities of magnetic resonance imaging in the diagnosis and surgical planning stages of treatment. One project involves improving the information surgeons can obtain from computer imaging prior to open-heart surgery. Another project is developing MRIs that can more accurately identify benign and malignant tissue, minimizing the need for tissue biopsies.

Also in this issue is a PITA success story focusing on the connections that industry is making with graduating students to foster and keep technical talent in Pennsylvania. Paul Ohodnicki’s journey from Carnegie Mellon graduate student to PITA industry participant speaks to this.

In closing, we wish to thank our industry partners, the Pennsylvania General Assembly, Governor Rendell, and the Pennsylvania Department of Community and Economic Development (DCED) for their continued support. This support enables PITA to continue to advance Pennsylvania’s economy through knowledge and technology development in partnership with industry.

MESSAGE FROM PITA CO-DIRECTORS
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Medical imaging is a field which uses machines to non-invasively visualize human anatomy. Clinicians use these images to diagnose disease or injuries, place medical devices, monitor treatment, and plan for procedures. Recently, researchers have begun to apply sophisticated computational techniques to these images to create 3D reconstructions, harvest more valuable data, and as a result, plan procedures that are less invasive and more accurate.

Two groups of PITA-funded researchers at the Institute for Complex Engineered Systems (ICES) have been collaborating with Pittsburgh-area medical schools and facilities to enhance the capabilities of magnetic resonance imaging (MRI) in the diagnosis and surgical planning stages of treatment. In one research project, professors Kerem Pekkan, Levent Burak Kara, and James Antaki are working to improve aortic root reconstruction surgeries by improving the information that can be obtained by a computer and help surgeons plan prior to open-heart surgery. In another project, professors Gustavo Rohde and Jelena Kovacevic are “teaching” MRIs to be more accurate by relating it to histology image data, from which pathologists can obtain more specific tissue information.

Pekkan, Kara, and Antaki are collaborating on their research with professors and physicians from the Center for Thoracic Aortic Disease; the Center for Heart Valve Disease; and the Heart, Lung, and Esophageal Surgery Institute at the University of Pittsburgh Medical Center (UPMC). Aortic root reconstruction and valve surgeries are complex, three-dimensional, open-heart operations requiring advanced surgical mastery and art for the best outcome. Pre-surgical customized planning is essential to reduce the amount of time a patient will be on cardiopulmonary by-pass during the operation. However, because of the complex features of the aortic root and variations of its structure for different patients, current pre-operative image data is often incorrect, requiring surgeons to make improvised and trial-and-error decisions during surgery.

Pekkan, Kara, and Antaki’s goal is to provide clinicians with an interactive anatomical design tool which allows patient-specific virtual aortic reconstructive root surgeries to be performed ahead of time by the computer. This process will allow surgeons to plan by providing answers to various “What if?” surgical scenarios for each patient and to assess their relative merit. The tool also provides a computational analysis of a patient’s potential blood flow through the repaired aortic pathway. The team recently started to incorporate automated engineering optimization techniques in hemodynamic pre-surgical planning.

The capability of CMU sketch-based surgical planning and anatomical editing tool is seen in the top picture as applied to coronary artery perfusion, a major component of aortic root, as shown in the lower picture.

Article continued on back cover...
Iron has been used by mankind for thousands of years and is the most widely used metal nowadays. Researchers at Lehigh University believe they have identified yet another use for iron – particularly scrap iron – which could not only help minimize the waste that scrap iron creates but also help clean up contaminated water.

Associate Professor Wei-xian Zhang and colleagues at Lehigh University and Tongji University in China recently completed one of the largest projects in the world to assess iron in environmental remediation. Rather than use the conventional iron powders that have become the norm in such water treatment techniques, Zhang turned to iron shavings obtained from local metal-processing shops, which are available in abundance at a relatively low cost.

The six-year project set out to explore the technical and economic feasibility of using iron shavings, which may have otherwise ended up in the scrap heap, for the enhanced treatment of industrial waste water. A bench-scale experiment was carried out for six months during 2003-2004 at an industrial park in Shanghai. The treatment plant received waste water from more than 50 small to medium sized factories, many of which produced dyes, pigments, petrochemicals, and pharmaceuticals, and proved effective at removing most of the contaminants from the water supply.

The project graduated in 2005 to a pilot test in which 2000kg of iron shavings were used to treat 12,600 gallons of water per day. The proven success of the addition of iron shavings to the water treatment process led to the Shanghai city government approving a full-scale treatment reactor in the Taopu district of the city, capable of processing almost 16 million gallons of water every day. The iron reactor contains almost one million kilograms of iron shavings and has been in continuous use since first connected in August 2006.

Professor Zhang states, “The addition of the iron reactor improved immediately and substantially the quality of water in the treatment plant. Following the success of the project, we have been invited by several municipalities to assess the feasibility of the combined iron–bio process for treatment of wastewaters from a variety of industrial processes. We may have opened up a new chapter in industrial waste treatment.”

As well as iron shavings, Lehigh researchers have also pioneered the use of nano-sized iron particles in comparable water treatment techniques, which are now widely used in many parts of the world. Due to their greater surface area, nano–particles have been shown to have greater reactivity than more granular sizes and are, therefore, potentially more efficient at removing contaminants from water. Nano–iron reaction rates can be also as much as 10,000 times higher than conventional iron particles and, when suspended in solution, are easily injected into underground water sources without the need for extensive underground work.

“This opens the potential for portable water treatment systems that can be easily implemented at low cost,” Professor Koel explains: “Research at Lehigh shows that nano–iron can degrade a wide variety of environmental contaminants including PCBs, chlorinated hydrocarbons, chlorinated pesticides and perchlorate. Degradation of a widely used pesticide, lindane, which has been shown to have harmful side effects in animals, for example, was found to be over 95 percent following treatment with iron nano–particles for 24 hours.” A field experiment in New Jersey has further highlighted the potential of the technology.
Funding from the Pennsylvania Infrastructure Technology Alliance has enabled the Lehigh researchers to examine the applications and potential implications of iron in the environment while collaborating with PA industry. These researchers have partnered with Lehigh Nanotech LLC, a knowledge-driven firm in Bethlehem, PA, focused on the development of new and value-added nanomaterials for environmental remediation and wastewater treatment. Lehigh Nanotech is conducting several pilot scale field projects using nano-iron to remediate contaminated groundwater, while working with Keystone Innovation Zones and the City of Bethlehem to improve the city’s wastewater treatment plant.

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Paul Ohodnicki believes strongly in the success of the Pennsylvania Technology Alliance Project (PITA) program. Upon graduating from Carnegie Mellon with a Ph.D. in materials science and engineering (MSE) in 2008, he accepted a position as a R&D researcher at the Glass Business and Discovery Center of PPG Industries, in Cheswick, PA. Prior to this, Ohodnicki also had the opportunity during his graduate studies to work closely with Magnetics, a division of Spang & Company, a local Western Pennsylvania company.

“These industry interactions were largely made possible through funding provided by PITA for a collaborative research project.” Ohodnicki states. In addition, he acknowledges, “the program played an important role in helping me to find permanent employment and stay in Pennsylvania through its linkage of employers and researchers at Pennsylvania universities.”

Beyond benefitting from the PITA program, Ohodnicki was and continues to be an advocate of the program. As a student, he and a few of his colleagues formed a graduate student group called CrossLink within the MSE Department, using a small amount of PITA funding and resources.

“Our goal in forming CrossLink was to develop a mechanism to promote these interactions and to better educate students about the regional opportunities they are most interested in throughout their graduate school career,” Ohodnicki explains. CrossLink promotes networking between Ph.D.’s from regional companies and graduate students throughout their graduate student career.

“Because post-graduate employment decisions are complicated for Ph.D. students by issues such as technical specialization area and career goals, providing them with information about regional opportunities and allowing them to interact regularly with regional Ph.D. professionals from their own technical field increases the chance that a good match will be realized.”

Since the group’s establishment in 2006, many PA-based companies and organizations have sent representatives to speak with students at CrossLink meetings, including Alcoa, PPG Industries, Bayer Materials Science, Seagate Research, Westinghouse, and the National Energy and Technology Laboratory. Upon graduation, a number of CrossLink Ph.D. students have accepted positions at PA-based companies, such as PPG Industries, Bettis Atomic Power Laboratory, Allegheny Ludlum, and Latrobe Specialty Steel.

Since he began working at PPG Industries last year, Ohodnicki supports CrossLink now as an industry participant, helping to continue to make connections between students and local industry. “On a personal level, I have been the very fortunate recipient of a wealth of educational opportunities available in this region,” Ohodnicki recounts. “I decided to work with other Ph.D. students to form CrossLink because I saw it as an opportunity to take advantage of my unique perspective to give back to my community in a relevant way.”

Ohodnicki says of the PITA program, “it has resulted in an increased general awareness of the activities and existence of PA-based companies on campus through such interactions. My own personal experience has shown me that this is particularly important for Ph.D. students with a specialized and narrow skill set looking to identify a company that could benefit greatly from their particular area of expertise.

To date, the PITA program has enabled nine start-up companies affiliated with PITA-sponsored technologies, funding over 700 technology projects in partnership with more than 322 Pennsylvania companies, obtaining more than $2.20 of leveraged funding from federal and industry resources for every $1 of state funding. The program has mobilized more than 340 faculty members and 1000 students to work on Pennsylvania-specific technology, education and outreach projects.

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Most power plants around the country are operating well beyond their original design life of 30 to 40 years. This is necessitated by the prohibitive cost of building new facilities. In order for these older plants to provide reliable power, it is necessary to find ways to prevent the failure of their aging tubes and pipes. This can be a challenge, however, because each power generation station has pipes made from different kinds of steel welded together in places which are prone to breaks.

With funding in part from PITA, Lehigh University Professors John DuPont and Joachim Grenestedt are leading a team of Lehigh researchers from the Departments of Materials Science and Engineering and Mechanical Engineering to address the problem of failures in these “dissimilar welds.” They are working in collaboration with PPL Corporation. Headquartered in Allentown, PA, PPL controls or owns more than 12,000 megawatts of generating capacity in the United States, sells energy in key U.S. markets, and delivers electricity to about 4 million customers in Pennsylvania and the United Kingdom.

In generating stations, both carbon steel piping and stainless steel piping are used. Inexpensive carbon steel pipes are generally used at locations of low stress and temperature where strength and corrosion resistance are not a primary concern. Other locations within the plant operate under higher temperatures and more corrosive atmospheres that require the use of stronger and more corrosion resistant stainless steels. At some point within the plant, these two types of alloys must be welded directly together, and a “dissimilar weld” is formed. Unfortunately, the sharp change in alloy composition that occurs across these connections leads to dissimilar weld failures, which are a common cause of forced outages for power plants. The cost associated with them is significant, as a single failure can cost a power company up to $850,000 per day in downtime and lost revenue.

DuPont and Grenestedt are creating a method for avoiding failures by developing design methods that can be used to establish the optimal change in composition required across the weld joint and developing fabrication methods with the required changes in alloy composition. Their method creates a “graded transition joint” that eliminates the sharp changes in composition associated with dissimilar welds, thus eliminating the source of failure.

With this approach, small pipes are fabricated that match the carbon steel composition on one end, the stainless steel composition on the other end, and then have a gradual change in composition across the pipe. The small transition pipe can then be inserted between the carbon steel and stainless steel pipes, and two similar welds can be made in place of the one failure-prone dissimilar weld. Different types of transition joints are currently being fabricated and tested with the goal that PPL Corporation will eventually install the graded pipes into its plants for long-term service testing. If successful, these transition joints can lead to significant savings associated with eliminating costly dissimilar weld failures. The results are also expected to be applicable to nuclear power generation plants.

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PITA funding has provided seed funding for the team to realize the first version of their tool, and they are using this funding toward collaborative National Institutes of Health and NSF grants, involving Carnegie Mellon and UPMC faculty and focusing on broader patient-specific cardiovascular surgical planning research issues.

Professors Gustavo Rohde and Jelena Kovacevic, from biomedical engineering, and electrical and computer engineering, are collaborating with Dr. John Ozokek, assistant professor of pathology at the University of Pittsburgh Medical School to create more accurate imaging procedures with the hope that some invasive medical procedures can be avoided. The typical method of testing tissue for pathology includes removing the tissue after a noninvasive radiological imaging procedure (usually an MRI) has detected an abnormality. Biopsying tissue samples, however, are invasive and can cause hemorrhaging, pain, significant patient and family anxiety, and in rare cases, organ loss. Rohde and Kovacevic’s PITA-funded research is to develop methods for relating information from histology images to the information present in MRIs. If certain relationships can be decoded with the aid of computations, it may be possible to better interpret MRIs without need for tissue biopsies.

In both of these instances, PITA-funded researchers are collaborating with University of Pittsburgh medical doctors and researchers to make medical procedures more efficient, accurate, and safer for the patients that must undergo them. On a larger scale, they are collaborating in ways that will help to innovate other areas of medicine and impact the overall field and practice.

(Left) A magnetic resonance imaging (MRI) machine.

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