MPI Newsletter - Fall 2009

Welcome

It's my pleasure to present our fall newsletter. As you'll see in the following articles, the MPI faculty, staff, and students have been hard at work writing proposals and doing research to benefit all our industrial partners. Even in these challenging times, MPI has made significant accomplishments during the past months. We have written several successful proposals—from starting a new center in Recycling to doing research for a New Energy Efficiency and Carbon Reduction project—HyperCAST.

This has also been a time of celebration. Diran Apelian was officially inducted into the National Academy of Engineers on October 5 in California, and we congratulate Roger Fabian, recipient of the 2009 George Bodeen Award Heat Treating Achievement Award in Indianapolis. Geoffrey Somary, a longtime supporter of CHTE, has been named CEO of Ipsen, and Rick Sisson has been appointed Dean of Graduate Studies at WPI. MPI folks are on the move and making a difference!

We have asked several members to give us their perspective on the value of being an MPI member, and their replies appear in this issue. Feel free to contact those members directly if you are considering joining one of our centers—or you may call me for membership details.

I extend my personal thanks to all of you who support the Institute, especially in these difficult times.

—Carol Garofoli

From the Director

I write this note with a great deal of optimism, due in part to the events of the past six months, and, more important, the fine character of the people of MPI in action— here at the university as well as in industry. It is, after all, the character and the commitment of the team that will enable us to endure and overcome adversity. It's been said that smooth seas do not make skillful sailors; indeed the seas have not been calm, and our sailors have shown their mettle (or ... metal!).

For the past two decades the consortia of MPI have grown and prospered, but the events of the past year—with the challenges facing the automotive industry and the supply chain serving that industry—have created an adverse situation for MPI. As difficult as it has been, everyone has pulled together, and we've been able to ride through the roughest storm I have witnessed in my professional life. I know I speak for all of my colleagues here at MPI when I say that we appreciate and cherish our industrial partners, who are much more than consortia members. They are true friends! This is best captured by the words of John Churton Collins: "In prosperity, our friends know us; in adversity, we know our friends."

Thanks go to all our consortia members for their support. Special thanks to our boards who have jumped in with both feet and helped us navigate through these difficult waters.

MPI faculty members have been active in pursuing sources of revenues and funds to support the activities of the Institute and to carry out the mission. Over the last two decades, our business model has been that 60-70 percent of our funds came from the industrial sector and the remaining from the federal government. We have now changed this equation: 50 percent and more of the revenues are coming from the government.

Professor Makhlouf Makhlouf reports that with the help and leadership of NADCA we have initiated HyperCAST, a major program with colleagues at Colorado School of Mines, Case, OSU, and Purdue; its thrust is on energy efficiency and carbon reduction and we will be pursuing the development of Mg and Al composite alloys. We are part of a major proposal submitted by wTe corporation to NIST-TIP, Building U.S. Strategic Metals Competitiveness Through Integration of Advanced Sensor Technologies. Prospects look very good; the work will assist in the development of technologies that will enable us to have mini-mills of aluminum and reduce carbon footprint and energy usage. In collaboration with Northern Illinois University, Questek Corp., and South Dakota School of Mines, we have submitted a proposal to DOE titled, MidAmerica Wind Turbine Reliability Improvement Consortium. In addition, we have partnered with Colorado School of Mines, and submitted a major proposal for an I/UCRC (Industry University Cooperative Research Center) to the National Science Foundation (NSF) for a Center for Resource Recovery and Recycling. Professor Makhlouf and I are in the midst of submitting a proposal to NSF for funds to study L12 Phase Strengthened Aluminum Alloys.

As you can see we have not been idle, and I reconfirm that the adverse business climate has brought out the best in us and we are energized by the dedication and the vision of the team.

Best wishes for a beautiful fall season. We look forward to seeing you at our consortia meetings.

ACRC

Click here to read the meeting notes from the ACRC Spring 2009 meeting.

A Perspective from John Jorstad

ACRC is the finest foundry-related industry-university research consortium in the world. From its very beginning as the ACRL (Aluminum Casting Research Laboratory) at Drexel in 1984, a key to its success has been the relevance of its research program to the global foundry industry. That relevance is assured by the selection of every project by an industry steering committee and the oversight of every project by an industry focus group. Students doing research receive the guidance not only of an exceptional staff of professors but also of an exceptional staff of industry leaders. As a result, almost every student graduating out of the program at WPI has immediately become employed in a key position in the foundry industry; that is an accomplishment that no other such program can boast. In fact, it is a continuing irritation to me personally that the Foundry Education Foundation (FEF) will not affiliate WPI, the most relevant foundry education program in the Americas.

The ACRL moved from Drexel in 1990 when Diran Apelian was appointed provost at WPI. After serving in that post for six years, Apelian was named director of WPI's Metal Processing Institute (MPI), an industry-university alliance dedicated to advancing the state of the art throughout near-net-shape metal processing. MPI initially included the ACRL and a consortium dedicated to powder metal processing; in time, consortia dedicated to semi-solid processing and heat-treating were added. MPI brings fundamental understanding to existing processes, develops new methods, and addresses management-technology interface issues with input from its industrial partners. As was the case from the outset regarding the ACRC, though MPI's work is fundamental in nature, the context of the work has well-identified commercial applications and the research agenda is developed in close collaboration with its industrial partners. All segments of industry are represented within the consortia -- primary and secondary producers of metal, equipment manufacturers, suppliers, manufacturers and processors of parts and end users. Thus, MPI benefits from input and engagement across the spectrum of the metal processing industry and the technology supply chain is fully represented by the institute's corporate partners.

ACRC remains a key component of MPI. The emphasis on aluminum changed about 10 years after the move to WPI when the ACRC and SSM consortia of MPI were combined and projects on magnesium were added to the research portfolio.

Over the years, ACRC has provided the foundry industry with bright new talent, well versed in the very latest methods and technologies and able to take the industry-of-the-future to much greater levels of performance.

In specific technology areas, ACRC identified lower-cost heat treating schedules for automotive aluminum castings; it pulled together into a comprehensive volume the state of the art in semi-solid processing and has since developed lower-cost variations of SSM and expanded the published knowledge base to include all forms of

high integrity die casting (SSM, squeeze casting and high-vacuum die casting); it developed and published the most comprehensive data base to date of die cast mechanical and physical properties and casting characteristics together with a software for alloy development and to predict properties of new die casting alloy compositions; it discovered an important new understanding of Al-Si eutectic solidification and silicon modification; and it provided new insights into fatigue performance of aluminum casting alloys – those are just a few of ACRC's accomplishments.

Just as important as any of those project accomplishments is what ACRC has done for specific member companies. Ray Donahue has written a companion article that clearly outlines what ACRC has meant to Mercury Marine, and why Mercury Marine values so greatly their membership in the consortium. Mercury Marine is not alone—there are numerous such cases; some involve specific projects funded by member companies and intended for their benefit alone (although every discovery and accomplishment really benefits all member companies in the form of any fundamental understandings developed); some involve internships that allow specific company research to be performed under the guidance of WPI staff while preparing existing employees for advanced degrees; most involve staff helping member companies apply the findings of ACRC research to their individual needs.

MPI and ACRC have developed exceptional alliances with universities and research organizations around the world, thus serving as valuable radar regarding happenings throughout the global industry; behind the scenes, the staff of MPI and ACRC provide much-needed insight to member company executives regarding the global industry scene.

That is my view of the ACRC. In these tough economic times, it might seem difficult to justify the cost of membership in ACRC. But as Ray Donahue has said, the value of ACRC to each company is far more than the cost. I suggest that in these specific tough times a major foundry organization can ill afford not to be a member.

A Perspective from Ray Donahue

Dear ACRC current members, previous members, and potential members:

This is not a "Dear John" letter on why we are dropping out of the Advanced Casting Research Consortium (ACRC). Instead, let me tell you my story about the largest recreational, boat-engine manufacturer, and what it had to do to physically survive and to justify continuation as a member of the ACRC.

Since 1972, I have worked for Mercury Marine, the largest manufacturer of outboard and stern drive engines, a division of Brunswick Corporation, the largest manufacturer of boats (for these same motors). My job, in essence, is to bring and develop casting technology to Mercury Marine for this engine manufacturing business, which has included the purchase of (1) an equity interest in a lost foam gray iron foundry in Torrieon, Mexico, (2) the AMP Slurry-on-Demand, Semi-Solid Metal casting technology, and (3) a unique, lost foam facility in Fond du Lac that applies 10 atmospheres of pressure during solidification.

As you should be aware, the economic conditions of the last 18 months have never been this bad for the sales of boats and motors, where the purchase of this "discretional,""recreational" boat-motor package requires "a substantial loan." Further, recognize that the three descriptive items in quotations do not characterize the required and necessary conditions for the purchase of a house or an automobile. As such, sales of our boats and motors are off by over 60 percent over the last 18 months and, as a result, the company has had to decrease employment numbers in boats and motors by 60 percent. Brunswick has also consolidated and closed more than

half of its boat companies. Even worse was the possibility of bankruptcy. The company, as a goal, made "cash" king and attempted to turn whatever they could to cash. This included the very painful operation of closing and consolidating plants, because the capacity of our plants varied from at the worst 15 percent to at the best 40 percent. The program was successful, but very painful because the die-casting operations, machining operations, and assembly operations in Stillwater, Okla., are being transferred to Fond du Lac, Wis., the main campus, and the Stillwater plant with 35 years of operation will close. Traditionally Mercury Marine has had to borrow heavily in the first quarter to finance the manufacture of the products that are needed for the rest of the year, but Mercury did not have to borrow a dime this year because of the strong cash position of over $400 million, due to their cost cutting efforts, their plant consolidation efforts and the sale of their equity interest in the Torrieon, Mexico lost foam foundry.

Against the economic conditions described above, Mercury had to support, with a handful of metallurgists, its core casting manufacturing technology, which included for corrosion resistant aluminum alloys: pressurized lost foam, conventional die casting, die casting with large "salt cores," low pressure-die casting, "Slurry-on-Demand" Semi-Solid Metal casting, and for corrosion resistant, precipitation hardening, stainless steels: investment casting. Of particular significance for all die casting operations for Mercury parts is the fact that all the die casting alloys do not rely on iron for die soldering resistance but instead rely on strontium, at 0.05-0.07 percent, for die soldering resistance. As a consequence, the die castings made with these alloys have permanent mold mechanical properties in all cases because the iron levels are low, corresponding to the iron levels in A356.0.

The Mercury/Brunswick plan coming out of this "recession" for our nation and "depression" for the recreation boat-motor business is to be a stronger company. To me this means a company that is capitalizing on the unique benefits of its casting technology. Further, this means leveraging your casting resources with membership in the Advanced Casting Research Consortium (ACRC), which gives one (a) access to the latest practical casting research that can be used on the casting manufacturing floor now (with the emphasis on "practical" and "now"), (b) access to individual consortium members, on a personal basis in "one on one" shop talk dialog, for discussions over lunch, over supper, at a happy hour event before a scheduled museum tour, at a Focus Group meeting, etc., (c) the opportunity to get more deeply involved in the research as a Focus Group Chairman, and finally (d) access to a "new breed" of students trained in the latest foundry methods. And finally, separate from the above "leveraged, noncompetitive, research", more specific research, directed at the specific needs of an individual company, that would not be shared with other members of the ACRC consortium, can also be arranged with the WPI research team on an individual basis (because of one's membership in the ACRC). Further, any patents that WPI obtains from the ACRC research, such as those resulting from any of the Rheocasting work, can be used royalty-free by ACRC members.

Let me elaborate on these four benefits. At Mercury, Adam Kopper heads up our Slurry-on-Demand, SSM process. He is an MS graduate from the WPI program, trained in all the Thixocasting and Rheocasting process that Diran Apelian and M.M. Makhlouf have developed over the years. Without university trained foundry "new blood", like Adam Kopper, the foundry industry in the US would die. Thus, our future foundry industry depends on the trained graduates that are coming out of university programs such as the ACRC program. This point can not be overemphasized. For example, General Motors could not have built the several lost foam facilities they have in production, if well-trained graduates from WPI, like Scott Biedermann, were not available. These jobs for a lack of trained graduates would be candidates for India or China.

The research programs under study in the ACRC are both timely and relevant for the ACRC member companies because the ACRC steering committee selects the research projects that ACRC members submit and vote on.

Each project is directed by an industrial steering committee (not by the professor per se) through the Focus Group organizational structure. Once selected, the direction and progress of each ACRC research program stays on course because it gets "its marching orders" from the Focus Group and its Focus Group Chairman who reports back to the larger ACRC group. Every voice within the Focus Group is heard and given the proper attention in a "family" environment. In fact, the Focus Group on a semi-annual basis traditionally takes the students working on the program out to dinner for further discussions. The technology transfer of this research to individual ACRC member companies takes many forms. Sometimes the presentations and reports of the research are enough. Other times, networking with other ACRC member companies is involved. In fact, very likely the "networking" activity among ACRC members is the sanity check that often is needed to make the final commitment for a plant trial run or for production.

Mercury's experience as members of the ACRC has been all positive. ACRC research that measured the surface tension of aluminum as effected by strontium additions allowed us to explain why high additions of strontium (0.05 - 0.07 percent) provides "die soldering resistance" to low iron containing die casting alloys, such as AA 367.0 and AA 368.0. Marketing agreements with Alcan with the same alloys resulted because of ACRC networking with Martin Hartlieb, Fred Major, and Jeff Laplante. Mercury's adoption of "short term solution heat treating" was a direct result of ACRC research and networking with Franz Feikus of VAW Alminium. Mercury's near purchase of a production fluidize bed heat treating facility was a direct result of ACRC research and networking (and experimental trials) with Jay Keist (an MS graduate of WPI) of Arizotah. Our grain refinement practices and melt cleanliness practices are also the direct result of ACRC research and networking with ACRC members. M.M. Makhlouf has given us a new appreciation of the mechanism of strontium modification. John Jorstad has gone far beyond "just helping" us with our hypereutectic Al-Si alloy technology embodied in the Mercosil alloy that has an Aluminum Association designation 391.0. And off-line, Diran Apelian and his team have given Mercury new insights into our own proprietary salt core technology that we use to make the most complex die cast engine blocks and heads. And finally, Diran has introduced us to the energy saving benefits of immersion heaters and Isothermal Melting (ITM), which we have under consideration for our die casting melting and holding furnaces.

To survive in these times that in some ways are as bad as the great depression, particular for the recreational boat-motor market, resources such as casting resources, have to be leveraged in a noncompetitive manner as detailed above. If the ACRC had no funding, except for the membership fees of say 30 member companies, one could argue that the leverage ratio might be 20 if 2/3 of the ACRC research had applicability for your company. However, when one factors in the funding that the ACRC brings in from other agencies and from its own networking "alliances" with other universities, that leverage ratio exceeds 100 for ACRC members. In these survival times at Mercury where "cash" is king and "spending" is only for justified essentials and for programs with a six month payback, we have justified our membership in the ACRC, with the details I have itemized in this communication. I hope you can do the same.

Hope to see you at our next ACRC meeting.

Regards,
Raymond J. Donahue
Sr. Director, Advance Materials & Foundry Technology
Mercury Marine

ACRC Receives Funding for a New Energy Efficiency and Carbon Reduction

Project - HyperCAST

The ACRC will collaborate with university researchers across the country as well as NADCA and the U.S. Department of Energy on an innovative new research and development program that aims to maximize energy efficiency and reduce carbon emissions in the transportation system. This program, which is known as HyperCAST, focuses on the development of materials and processes for cast light weight components for passenger cars and commercial and military trucks. More specifically, the HyperCAST program is targeted at developing materials and processes for cast light weight frame, body, chassis, and powertrain components for fuel efficient passenger cars as well as commercial and military trucks.

The innovative materials to be developed within the context of the HyperCAST program are a new generation of cast aluminum and magnesium composite systems. Recent research efforts indicate that through a novel single-step auto ignition synthesis technique it is possible to produce metal matrix composite materials with substantially higher volume fraction of particulates (60 percent and above) than the typical volume fractions of 10-20 percent. The auto ignition synthesis technology also produces more uniform distribution of finer particles (on the order of 1 micron) than traditional methods. Moreover, it works with various types of reinforcing particles such as TiC, TiB2 and AlN. Preliminary estimates indicate that materials with a 20 percent improvement in tensile strength, fatigue strength and impact resistance over conventional composite materials are possible with this novel technique. Obviously, the processes to be used in casting these composite materials into usable components require development. Currently, it seems that high pressure die casting, semi-solid metal casting, and squeeze casting are the most suitable processes for making composites by the auto-combustion synthesis technique. However, several other casting processes are possible and will be investigated within the context of the research program. All in all, a minimum of four casting processes will be pursued and processing parameters will be defined for the successful production of cast components of both aluminum and magnesium base composite materials. In order to support the overall process development, computer models will be developed to understand the flow characteristics of the new materials, die materials and coating systems will be evaluated in order to select suitable systems that can provide resistance to the anticipated abrasiveness of the new composite materials, and recycling methodologies will be established.

According to U.S. Senator George Voinovich (R-OH) the ranking member of the Senate Committee on Appropriations' Subcommittee for Homeland Security, HyperCAST has been authorized as a four year program. Work began on the project in September 2009.

—Makhlouf M. Makhlouf

ACRC Student Research Projects

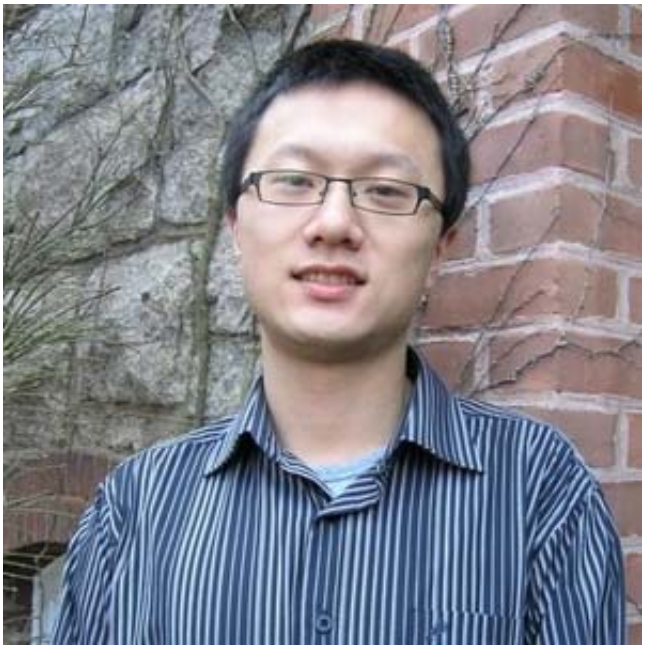
- Metal Matrix Nanocomposites for High Temperature Applications - Hao Yu
- Metal Matrix Nanocomposites Fabrication Feasibility Study - Cecilia Borgonovo
- Friction Stir Processing of Aluminum Alloys - Ning Sun
- Predicting the Response of Aluminum Casting Alloys to Heat Treatment - Lance Wu

Metal Matrix Nanocomposites for High Temperature Applications

Hao Yu, a research assistant under the direction of Professor Diran Apelian, is working on Metal Matrix Nanocomposites for High Temperature Applications. The project entails the challenging work of uniformly

dispersing nano-sized particles inside Aluminum alloys using electromagnetic force. Currently in the early stages of his research, Hao is concentrating on modeling the distribution of magnetic flux density and lorentz force. In addition, Hao is conducting trial experiments to verify the model.

— Hao Yu



Metal Matrix Nanocomposites Fabrication Feasibility Study

Cecilia Borgonovo is pursuing her MS at WPI under the direction of Professor Diran Apelian. Working as a research assistant at the ACRC, Cecilia is currently focusing on the feasibility of metal matrix nanocomposites fabrication. Specifically, she is testing an "in-situ" process involving the reaction between a gas and the liquid melt to form the reinforcement phase. The experiments in progress concern, as a first step, the verification of the process. Also, Cecilia is pursuing the development of a simulation model in order to couple all the parameters involved in this challenging process.

—Cecilia Borgonovo

Friction Stir Processing of Aluminum Alloys

Friction Stir Processing (FSP) is a recent outgrowth of the Friction Stir Welding (FSW) process and relies on solid-state deformation to modify the surface of the working surface/materials. FSP has been shown to locally eliminate casting defects and to refine the microstructure of alloys to improve their mechanical properties and enhance corrosion resistance. Such improvements have important implications for manufactured components for a variety of automotive and other industrial applications.

In Friction Stir Processing, a rapidly rotating pin tool is plunged into the surface of the component and is traversed across the surface to carry out the needed deformation. Frictional heating and extensive plastic deformation occur in the material causing considerable changes in the traversed area. Friction stir processed zones can be produced in metallic components to depths of about 50mm below the surface with a gradual transition from a heavily worked material at the surface to the underlying original material.

Ning Sun, a PhD candidate, continues to research Friction Stir Processing of Aluminum Alloys under the direction of Professor Diran Apelian. The FSP project will confirm and evaluate microstructure evolution during friction stir processing of aluminum alloys. In addition, Ning will investigate the potential of friction stir processing to form a particle-reinforced zone in standard Al cast components.

—Ning Sun

Predicting the Response of Aluminum Casting Alloys to Heat Treatment

It is well known that the mechanical properties of aluminum alloy castings can be greatly improved by a precipitation hardening heat treatment. Typically, this heat treatment consists of three steps: (1) solutionizing, (2) quenching, and (3) aging; and it is performed by first heating the casting to and maintaining it at a temperature that is a few degrees lower than the solidus temperature of the alloy in order to form a single-phase solid solution. Then rapidly quenching the casting in a cold (or warm) fluid in order to form a supersaturated non-equilibrium solid solution; and finally, reheating the casting to a temperature where nucleation and growth of the strengthening precipitate(s) can occur. Obviously, these processing steps involve significant thermal changes that may be different from location to location within the casting. The objective of this project is to develop a finite element model and the necessary material database that allow predicting these physical and material property variations. The commercially available finite element analysis software, ABAQUS, will be used. This software can perform many of the required calculations. For example, it can calculate the resulting distortion, residual stresses, and the thermal profile across the casting, but it is not capable of predicting the resulting room temperature mechanical properties.

In a recently completed ACRC project (Phase 1), a simpler model was developed and tested. The model used ABAQUS and a specially developed data base that includes the necessary heat transfer coefficients (measured using a specially designed quenching system) and mechanical properties (measured using a Gleeble machine). The structure of this Phase 1 Model is shown in Fig. 1 and requires 3 inputs: the quenching heat transfer coefficient, the initial conditions, and the boundary conditions on the casting; and it produces 3 outputs at each geometric node: the geometric distortion, the magnitude and type of residual stresses, and the thermal history.

In the newly initiated ACRC project (Phase 2), the focus will be on predicting the response of the casting to the aging step of the precipitation hardening heat treatment; i.e., the focus is on developing and adding to the existing model a module and a data base for predicting the resultant room temperature mechanical properties at each geometric node within the casting. The structure of the complete model is shown in Fig. 2.

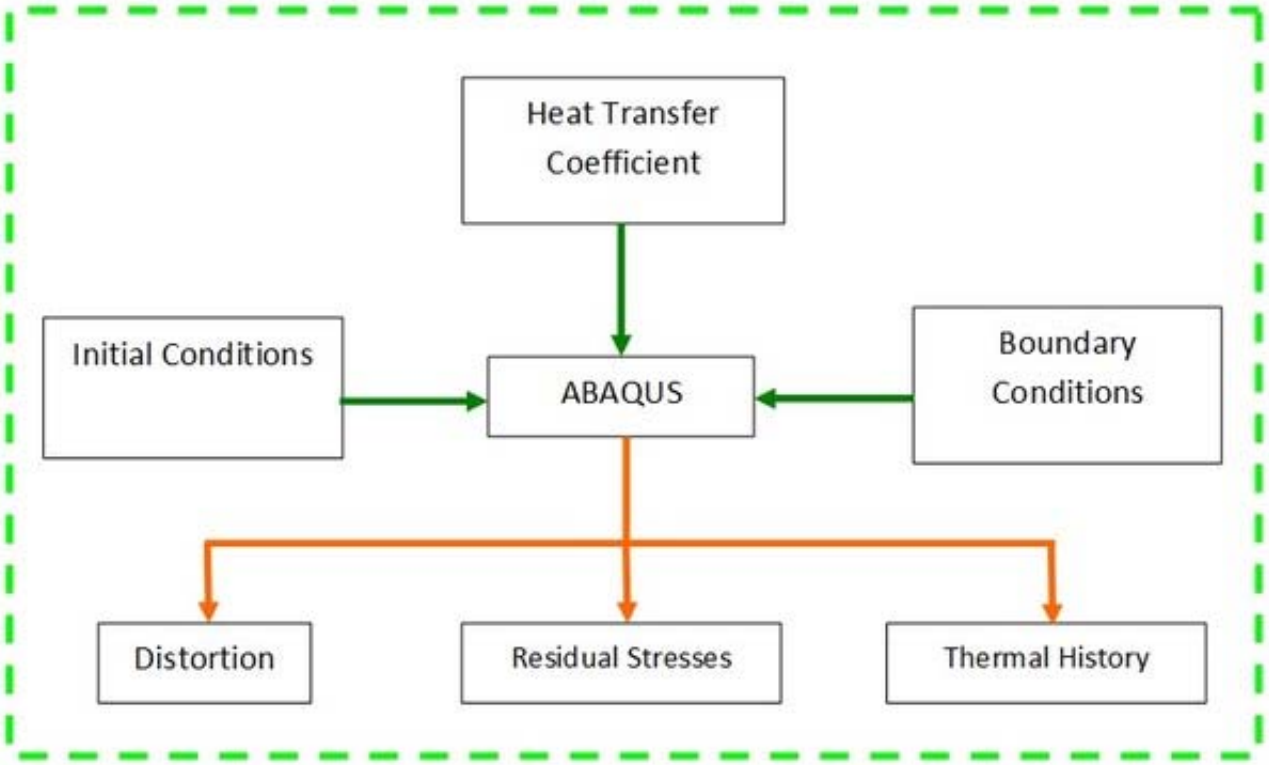


Figure 1: Structure of existing model.

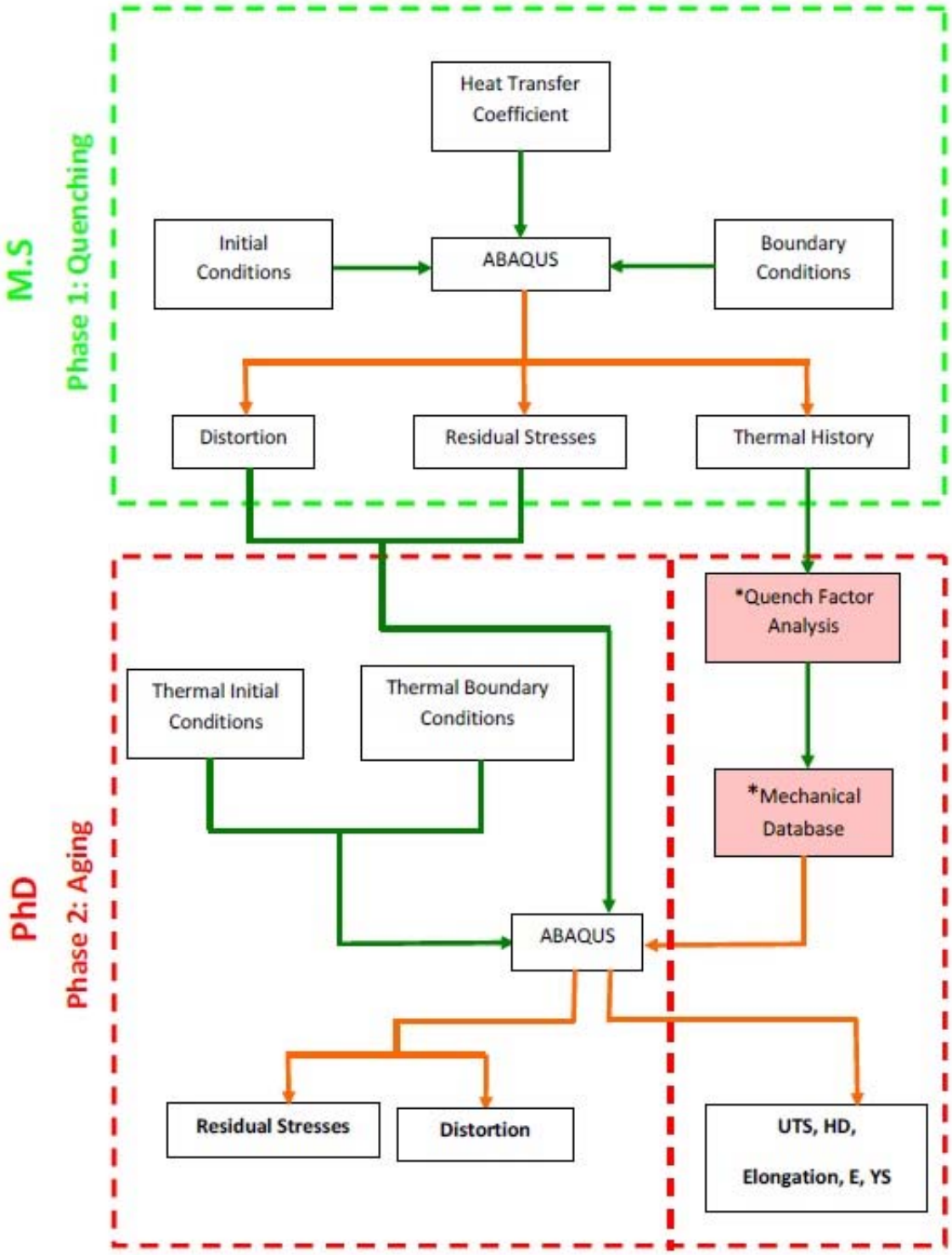


Figure 2: Structure of new model.

— Makhlouf M. Makhlouf and Chang-Kai (Lance) Wu (pictured)

CHTE

Click here to read the meeting notes from the CHTE Spring 2009 meeting.

A Perspective From Roger Fabian

The Center for Heat Treating Excellence (CHTE) is five years old and is now a solid member of the research community servicing metal working industries in North America as well as internationally. CHTE is part of the Metal Processing Institute (MPI) which is made up of four centers that do research in the following areas: casting, heat treating, powder metallurgy, and imaging and sensing. A newly planned center on recycling is scheduled to kick off early in 2010. CHTE is the only place where commercial heat treaters as well as captive heat treaters can meet and discuss research projects in a pre-competitive atmosphere.

CHTE looks at all aspects of heat treating and metal joining from the theoretical to the practical. Our members determine what projects the Center will work on. Examples of some of the projects are improving aluminum heat treating cycles, measuring coefficients of thermal conductivity, how to produce clean parts after heat treat and high pressure vacuum quenching. Check the website for a complete list of projects CHTE has undertaken.

With all of the consolidation that has occurred in our industry, there has been, in some cases, a reduction in technical competence within our industry. This results in a need to do research and development for heat treating and metal joining by outside sources. CHTE fills that bill.

Bodycote is a Platinum Member of CHTE. As a Platinum Member, we have access to and receive:

- Free consulting through the hotline for expert advise on material processing and business strategies;
- Office management systems, supply chain management, non-destructive evaluation, imaging and sensing, casting;
- Lean manufacturing as well as heat treating corrosion and hydrogen embitterment;
- Free computer modeling;
- Access to the metallurgical laboratory as well as use of WPI's SEM.

Can you imagine the benefit of having all of these experts and services within your company free of charge?

CHTE and MPI will place students within your company, allowing your company to initiate and complete projects which might be normally done by a staff engineer or metallurgist. This results in a completed project at a much reduced cost to your company. The value could be as much as $60,000. Our company has utilized this service to not only initiate a new process but to do the "grunt work" necessary to demonstrate its feasibility.

CHTE and MPI also offer the Industrial Internship Program which provides a qualified engineer onsite to complete or work on projects which would normally be done by more senior people resulting in completed projects on time with acceptable results.

Bodycote is high on CHTE because it provides us with a multitude of services and opportunities for research we would not be able to get done as efficiently and as cost effectively as we can utilizing the Center for Heat Treating Excellence and the Metal Processing Institute.

Contact Carol Garofoli (garofoli@wpi.edu) for membership details.

Roger J. Fabian
Business Development Manager
Bodycote plc
Berlin, CT

CHTE Students Attend Heat Treating Society Conference and Exposition

Professor Rick Sisson and the CHTE students attended in full force the Heat Treating Society Conference and Exposition in Indianapolis, Indiana during September 14-17, 2009. The CHTE graduate students made a fabulous impression on the heat treaters! They were the room monitors for every session and while visiting the show floor, they met many CHTE members and hopefully some future members.

CHTE presented six papers, three of which were co-authored with member companies (GM, CAT, and Air Products):

1. *The Effects of Quench Starting Temperature on Cooling Rates and Heat Transfer during Oil Quenching*
   X. Dai, M. Maniruzzaman, R.D. Sisson, Jr.

2. *Residual Stresses in Air Quenched 319 Aluminum Alloy Castings*
   B. Xiao, Q. Wang (General Motors), Y. Rong, G. Wang
3. *A Study on Heat Transfer Coefficient of High Pressure Hydrogen Quenching*
   B. Xiao, G. Wang, Y Rong
4. *Development of a Simulation Tool for Prediction and Optimization on Carburizing Processes*
   G. Wang, M. Maniruzzaman, R.D. Sisson, Jr.
5. *Atmosphere Carburizing Using Electric Discharge-Activated Nitrogen-Natural Gas Mixtures*
   Mr. Zbigniew Zurecki (Air Products & Chemicals, Inc.), Ms. Xiaolan Wang
6. *Multi-Objective Optimization of Gas Carburizing Process In Batch Furnaces with Endothermic Carburizing Atmosphere*
   O. K. Rowan (CAT) and R. D. Sisson

Finally for after hour's fun, the students enjoyed the sights and sounds of downtown Indianapolis and especially a night out at the Ram Brew Pub!

— Rick Sisson

High Pressure Hydrogen Quenching

MPI/CHTE sponsored the High Pressure Hydrogen Quenching (HPHQ) project to investigate the effectiveness of HPHQ and to determine if HPHQ can produce competitive results compared to oil quenching with regard to cooling rate and microstructure. However, there is a gap between the industrial application of HPHQ and the full understanding of this new technology. Studies of the related safety concerns and benefit and cost analysis are also required.

Gas quenching has several advantages over liquid quenching systems:

- The use of gas quenching can significantly improve obtaining near net shape of metal components.
- The cooling rate of gas quenching can be controlled more uniformly to minimize distortion by adjusting the heat transfer coefficient (HTC).
- Gas quenching is more environmentally friendly.

Hydrogen is used in gas quenching for a higher cooling rate and a lower gas price. HTC for hydrogen is 1.9 times of that for nitrogen and 1.3 times of that for helium, while the hydrogen price is 0.97 times of nitrogen and 0.1 times of helium. Because of the great performance-price ratio of hydrogen, HPHQ has earned its rightful place as a valuable weapon in the arsenal of the heat treater.

In conjunction with CHTE member companies, the WPI team, consisting of PhD candidate Bowang Xiao, Dr. Gang Wang, and Professor Kevin Rong, has made some achievements. The current practice, related literatures, and safety issues have been reviewed. HTC variation with respect to gas pressure and velocity has been studied. In addition, a series of FEA and CFD simulations have been conducted. These simulations show that HPHQ can cool parts as fast as oil quenching with improved quenching results under proper HPHQ conditions. Quenching results show better microstructure and lower distortion. Experimental validation is planned to further study the effectiveness and benefit of HPHQ.

— Bowang Xiao

Other Centers

This section is devoted to news of the CR^3, CIS, PMRC, and Sloan centers. In this issue, the new CR^3 center is featured.

Center for Resource Recovery and Recycling (CR^3) Workshop

As part of our NSF planning grant to form this Industrial/University Collaborative Research Center (I/UCRC), WPI and the Colorado School of Mines held a CR^3 planning workshop with industrial attendees in Golden, Colo., August 11-12, 2009. Its purpose was threefold: describe I/UCRC operating procedures, identify a research portfolio that addresses industrial resource recovery and recycling needs, and establish the center's vision statement.

The Industry/University Cooperative Research Center (I/UCRC) on Resource Recovery and Recycling will engage in the development of technologies and their transfer to industry with the goal of achieving materials sustainability. Resource productivity and societal sustainability demand that materials recovery and recycling be included from initial product design through manufacture to end-of-life disposition in a manner that yields both energy savings and profitability.

The industrial attendees then broke into two focus groups, chaired by Tom Meyer of Apogee Inc. and Jim Van Wert of Victaulic Corp. The groups created a list of 24 potential CR^3 projects, which address WPI's focus on metallic materials for structural applications as well as CSM's concentration on electronic and multifunctional materials. The project listing is quite diverse covering recovery and recycling issues for structural alloys, electronic scrap, rare-earth materials, photovoltaic materials, glass, and foundry sand.

—Dan Backman

CR^3 Workshop Attendees

CR^3 Takes Shape

Following the August CR^3 workshop, the center directors, Diran Apelian of WPI and Brajendra Mishra of CSM, have been hard at work recruiting industrial members, defining the initial set of research projects, and preparing the final NSF proposal to form this Industrial/University Collaborative Research Center (I/UCRC).

To date, 10 companies have committed to join, five associated with CSM (GE, H. C. Starck, First Solar, Surface Combustion, and Victaulic), five with WPI (ALCOA, Apogee, Argonne, Molycorp, and Tosoh). Several others are interested and will likely join CR^3.

The initial research portfolio for the center was created from the full list of projects identified by industry during the August workshop with a focus on those topics of greatest interest to the founding members listed above. These six projects cover proposed work at both schools:

1. Metal Recovery via Automated Sortation of Powdered Scrap (WPI)
2. Molten Metal Compositional Sensing to Enhance Scrap Recycling (WPI)
3. Development of an Alloy Recyclability Index and Strategies for Tagging to Facilitate Downstream Processing (WPI)
4. Physical and Chemical Beneficiation for Recycling of Photovoltaic Materials (CSM)
5. Production and Recovery of Rare Earth Metals (CSM)
6. Recycling of Foundry Sand through Chemical and Physical Beneficiation (CSM)

We are excited about the prospect of having our I/UCRC proposal accepted by NSF and the launch of CR^3 early next year. This center will strengthen MPI and expand our research and student exposure to recycling technologies that are increasingly important to both industrial partners and the nation. We will keep you apprised of our progress with CR^3 and we encourage you to contact us regarding your recycling needs and your interest in joining this new center.

—Dan Backman

MPI Labs

MPI has many tools and equipment available to its members. A full list of our lab equipment can be found here. The newest addition to our labs is the SPECTRO MAXx M, supplied by SPECTRO Analytical Instruments.

New Optical Emission Spectrometer

A new optical emission spectrometer (OES), SPECTRO MAXx M, supplied by SPECTRO Analytical Instruments, has been installed in our lab. It is being used in ACRC and CHTE research to accurately determine the chemical composition of alloys being developed or used in our projects. The OES will be used in CHTE research to measure the carbon and nitrogen concentration profiles in carburized, nitrided, or carbonitrided steels. The profiles will be compared to computer predicted profiles to validate the models. The ACRC team will use the OES to determine the alloy compositions for new aluminum and magnesium alloys.

Software Capabilities

Among the many tools available to MPI are an assortment of software packages to aid in research. These include the following:

LabView is a graphical programming language that has revolutionized the development of test, measurement, and control systems. Its unique programming interface allows MPI researchers to record vital data quickly and accurately.

DASYLab complements the features of LabView, thereby increasing the flexibility of MPI's data acquisition

systems.

JmatPro is a cross-platform program that calculates a wide range of materials properties for alloys, in particular multicomponent alloys used in industrial practice. MPI uses JMatPro to calculate solidification, mechanical, chemical, and thermo-physical properties that aid in our research ventures.

Pandat is an integrated computational environment for phase diagram calculation and materials property simulation of multi-component systems based on the CALPHAD approach.

MAGMA is the world's leading casting process simulation tool for foundrymen, tool makers, and casting designers. MPI uses MAGMA to process layout and optimization of castings.

INSTRON is a testing suite composed of various modules, allowing MPI to experimentally build material characterization models.

SolidWorks is a leading parametric solid modeling program that MPI uses to build accurate representations of prescribed geometry.

SolidWorks Simulation is a set of analysis tools used for static dynamic loading, fatigue and drop tests, flow simulation, and more.

Pro/ENGINEER is a widely used solid modeling package used for increasing the compatibility of MPI's services with more companies.

Pro/MECHANICA is a design validation package whose features mirror those of SolidWorks Simulation.

Unigraphics NX CAD/CAE/CAM package is used in the product development process from concept modeling to design validation to manufacturing.

Simula Abaqus is one of the most widely recognized and relied on design validation packages, allowing our MPI researchers to tackle nearly any CAE problem.

COMSOL is a partial differential equation solver whose capabilities are limitless. MPI has used COMSOL for many applications, including modeling of particle flow during casting of particulate composite materials.

MATLAB is a technical computing package. MATLAB's features are vast and aid in many different operations at MPI including post-processing of data and image analysis.

MathCAD is an engineering calculation package that aids in the processing of data collected during research.

People

This section is devoted to news and updates from the many people of MPI, including past and current members, students, faculty, and staff. Click on the links below to catch up on these people:

- Bruce Boardman
- Animesh Mandal
- D. Scott MacKenzie

- Yiming (Kevin) Rong
- Richard Sisson
- Geoffrey Somary

Bruce Boardman

After 40+ years in materials engineering at Deere & Company, Bruce Boardman is taking the big step and retiring. According to Bruce, "it's been a great ride and I've enjoyed every minute of it (well, almost every minute)." He plans to stay active in the profession for many years to come. Bruce would like to hear from his friends at his new email address: Boardman@Geneseo.Net.

Animesh Mandal

After two years as a post doctoral fellow with Professor Makhlouf, Animesh Mandal joined the Institute of Minerals and Materials Technology (IMMT) as a scientist in the Advanced Materials Technology Department. He is working on light metals casting. His primary roles are to upgrade the laboratory facilities and to develop new alloys for commercial application.

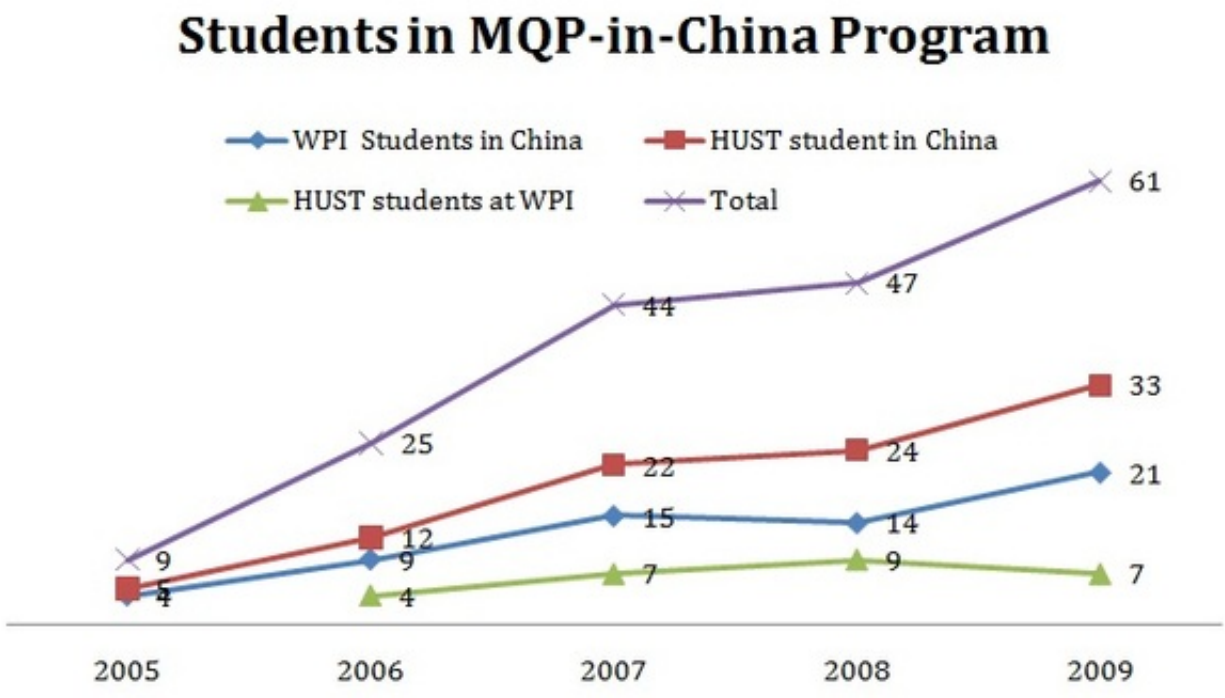
IMMT, located in Bhubaneswar, eastern India, was created in 1964 as a premier establishment for the Council of Scientific and Industrial Research (CSIR). The institute specializes in providing R&D support for process and product development with a special emphasis on conservation and sustainable utilization of natural resources.

D. Scott MacKenzie

Scott MacKenzie co-chaired the Heat Treating Society Show in Indianapolis, with Fred Specht (Ajax-Tocco) and Dale Weires (Boeing). More stories of the conference can be found throughout the newsletter. On October 27, Scott will attend the 4th Asian Heat Treating Conference and Exposition in Beijing.

Kevin Rong - MQP Program in China Expands

The MQP program in China has continued to expand since its first year, 2005. This summer professors Kevin Rong and Amy Zeng (Management) traveled with 21 WPI students to China and worked with 34 students from Huazhong University of Science and Technology (HUST) in Wuhan, Southeast University in Nanjing, and Beijing Jiaotong University (BJTU). Figure 1 shows the numbers of WPI students involved in the program.



Despite the economic downturn, we successfully identified project sponsors. The students worked in 10 mixed teams on eight projects sponsored by Caterpillar, Caterpillar; CIS, Wuxi; Saint Gobain; Jiangsu Aucksun Metal, BASF-YPC, and The Second Construction Company of Sinopec, as well as HUT and BJTU. Projects covered topics from mechanical design, robotics sensing, and control, to green production, lean manufacturing, and supplier chain management.

The four female and 17 male WPI students represented a broad spectrum of the WPI population (their majors include mechanical engineering, manufacturing engineering, management engineering, electrical and computer engineering, robotics engineering, and mathematical sciences). They hail from the US, Japan, Brazil, Vietnam, Korea, China, the Philippines, Jamaica, and India.

On July 31, the students made remarkable final presentations at the HUST campus to an audience of 100 that included project sponsors and representatives from other companies and universities. The sponsors showed great satisfaction with the projects, one of which will continue with a phase 2 target. Several students received interviews for possible internships or permanent positions, something rather unusual in China. All the students from both sides of the world have practiced and learned a lot from each other and from the program. We can expect an even bigger expansion of the program next year.

Richard Sisson

In July, Professor Richard Sisson began his tenure as dean of graduate studies at WPI. He is responsible for the overall operations of the Office of Graduate Studies and serves as principal advocate for graduate programs across all disciplines. In addition, Rick will continue as a faculty member in the Mechanical Engineering Department.

Geoffrey Somary

Geoffrey Somary has been appointed president and CEO of Ipsen Inc. Since 2005, Geoffry served as president of VFS Corporation and most recently as COO and as such played a key role in Ipsen's growth initiatives.

Awards and Recognitions

Many in MPI have been honored with awards, recognitions, and appointments since our last newsletter. We congratulate the following people for their achievements:

- Diran Apelian
- Rathindra (Babu) DasGupta
- Roger Fabian
- Olga (Olly) Karabelchtchikova

Diran Apelian

During the 2009 Commencement ceremonies at WPI, Diran Apelian was presented with the Chairman's Exemplary Faculty Prize for "his extraordinary achievements as a researcher and educator, his national leadership in metals processing, and his tireless devotion to the cause of innovation in engineering education." The prize was established in 2007 to recognize faculty members who, as true exemplars of the university's highest aspirations and most important qualities, excel in all relevant areas of faculty performance.

On October 4, 2009, Diran Apelian was inducted into the National Academy of Engineering (NAE) at their Annual Meeting in California. Election to the NAE is among the highest distinctions accorded to engineers. Established in 1964, NAE consists of the nation's premier engineers, who are elected by their peers for seminal contributions to their fields. Operating under the congressional charter granted to the National Academy of Sciences in 1863, the academy provides leadership and guidance to government on the application of engineering resources to social, economic, and security problems. There are currently 2,246 NAE members.

Pictured with Diran are Dr. Irwin M. Jacobs (l) and Chuck Vest (r).

Preceding the induction ceremony at the home of Bob Hart '79, a WPI alumni event honoring Diran was attended by several of his colleagues and former students.

Rathindra (Babu) DasGupta

Babu DasGupta, I/UCRC Program Director, was honored with the NSF Director's Award for Collaborative Integration pertaining to his work on the Gen-3 Engineering Research Centers Program (ERC) Team.

Roger Fabian

During the ASM Heat Treating Society Conference and Exposition on September 16, 2009, **Roger Fabian**, business development manager for Bodycote Thermal Processing, received the 2009 George H. Bodeen Heat Treating Achievement Award. Established in 1996, this award recognizes distinguished and significant contributions to the field of heat treating through leadership, management, or engineering development of substantial commercial impact. Roger was recognized "for continuing efforts to foster heat treating knowledge as a science and for vision and leadership in the formation of the ASM Heat Treating Society and the Center for Heat Treating Excellence."

Olga (Olly) Karabelchtchikova

Olly Karabelchtchikova has been appointed to the ASM Emerging Professional Committee. In this leadership role, she will be a member of a team that is a key component in making ASM strategic plans a reality for it's membership.

Calendar and Reminders

MPI Meeting Calendar

- November 10, 2009 - CHTE Board Fall meeting (3:30pm - 6:00pm)
- November 10, 2009 - CHTE member reception and dinner (6:30pm)
- November 11, 2009 - CHTE member meeting (8:00am - 4:00pm)
- December 1, 2009 - ACRC Steering Committee Fall meeting (3:30pm - 6:00pm)
- December 1, 2009 - ACRC member reception and dinner (6:30pm)
- December 2, 2009 - ACRC member meeting (8:00am - 4:00pm)

Related Meetings and Conferences

- October 25-28, 2009 - MS&T '09, Pittsburgh

Notices

We are always glad to receive items of interest to MPI News readers. Please send articles for the next edition of the newsletter to Renee Brodeur (rbrodeur@wpi.edu).

From the MPI Accountant

Invoices for fiscal year 2009-2010 were mailed on July 1. As of November 1, only 47% of the MPI center memberships have been paid. Please mail your payments in soon. Your payments are important for continuing the great work done by our faculty, staff, and students. If you should have any questions or concerns, please contact Renee Brodeur at rbrodeur@wpi.edu.

MPI Bookmarks

- MPI
- ACRC
- CHTE
- CIS
- CR^3
- Hotline
- Other News of MPI and past Newsletters

WPI in the News

Since the last MPI newsletter, WPI has made headlines in some prominent publications and websites. Here are a few WPI news releases that may be of interest to you:

- WPI Moves Up in U.S. News & World Report Rankings
- WPI Ranks Among the Top 10 of Schools that Produce the Best-Paid Graduates in a Payscale.com review
- Princeton Review Ranking: WPI Home to 'Happiest Students'
- New York Times Features WPI's Sustainability Success
- WPI Proves to be one of Academia's Biggest Sustainability 'STARS'
- WPI's East Hall Awarded Gold LEED Certification
- Entrepreneur Reports that WPI is Rated the Top 15 MBA Programs Nationwide in the Finance Category of Princeton Review Student Survey

To read other WPI news releases, click here.