Zinc Coating of High-Strength Steels
The Key to Ultra-Light Auto Body Design

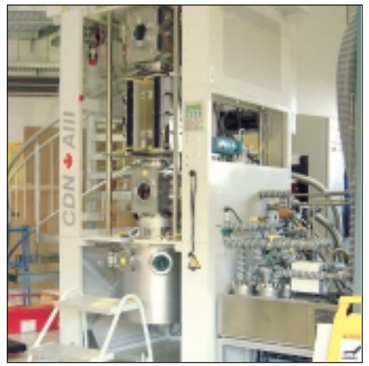
In an age where technology has become synonymous with silicon chips and software, the iron and steel industry is viewed by many as an artifact of a smoke-stack era that is quickly fading from the scene. Look a little closer, however, and one sees a different picture. In the former rust belts of the United States and the steel towns of Canada the steel industry has ambitious plans to revive its sagging fortunes, and new technology is paving the way.

The success of these plans rests, in part, on research underway at McMaster University. With the aid of industry partners like Dofasco and Stelco, McMaster is helping to secure the future of steel with groundbreaking research in metallurgy and industrial processing.

One of those heading up the effort is Dr. Joe McDermid, associate professor in McMaster's Department of Mechanical Engineering, and the Stelco/NSERC Industrial Research Chair in Steel Product Application. Dr. McDermid's Chair is the newest component of the McMaster-based *Steel Research Centre*, an organization dedicated to finding solutions to the engineering challenges facing the steel industry.

Before coming to McMaster in August 2003, Dr. McDermid worked for 11 years at the Noranda Technology Centre, where he developed his expertise in the galvanizing and galvannealing of steel. Galvanizing is a zinc coating process that provides steel with corrosion resistant properties and improved surface quality. Dr. McDermid's current research challenge is to make these same processes work with the new generation of high-strength dual phase (DP) and transformation induced plasticity (TRIP) alloy steels that are being developed for application in advanced automotive designs.

New ultra-light cars may be on the roads sooner than you think if Dr. Joe McDermid's research can solve the galvanizing puzzle.



"Rhesa" galvanizing simulator.

Steel producers stand to benefit greatly from the success of Dr. McDermid's research. The automotive industry worldwide faces increasing demands from environmental protection agencies to build more fuel-efficient vehicles. While there are several ways this can be achieved (hybrid cars, for example), the most straightforward approach is to build lighter-weight vehicles using advanced materials, such as high strength-to-weight-ratio steels. A 2002 study sponsored by the steel industry showed that vehicle weight savings of at least 25% could be achieved by utilizing ultra-light steel auto body designs employing DP and TRIP steels.

The galvanizing of these steels, however, presents a problem. While advanced steel alloys offer the high strength-to-weight ratio that auto manufacturers seek, their higher alloy content also results in a surface structure that resists the zinc coating process.

Galvanizing Simulator

To study this issue in more detail McMaster's Steel Research Centre has recently acquired a new state-of-the-art galvanizing simulator and has also received the donation of a galvanizing simulator from Noranda Inc. The former machine, a *Rhesa simulator*, was purchased with the assistance of a $1.8 million grant from the Canada Foundation for Innovation (CFI), and is one of only three such machines located in academic institutions world-wide (and the only one in North America). Both machines are capable of replicating all the critical phases of the galvanizing process and will be used to explore the fundamental science of the metallic coating process and its effect on material properties and manufacturing.

Dr. McDermid's Research Chair sponsor, Stelco Inc., is contributing to the work in several ways. In addition to funding the Research Chair itself, the company has agreed to provide a significant portion of the steel for processing in the simulator and will help to benchmark the results with samples of the same steel processed at its Z-Line galvanizing facility at Hamilton's Hilton Works. The company will also donate significantly to the Chair's success through the donation of mechanical testing and analytical chemistry time and through the construction of several pieces of custom apparatus.

The benefits of the research will be shared by all the companies participating in the Steel Research Centre – a group that includes Stelco, Dofasco, Ipsco, Bluescope Steel, Iron Ore Company of Canada, Hatch, Air Liquide, Reference Metals and Noranda. ■

For futher information, please contact Dr. Joe McDermid, Associate Professor, Department of Mechanical Engineering, McMaster University, mcdermid@mcmaster.ca.

MMRI
McMaster Manufacturing Research Institute

The McMaster Manufacturing Research Institute – one of the country's most advanced and best equipped research laboratories – combines research excellence with state-of-the-art equipment to meet the sophisticated research and development needs of leading manufacturers. Created in 2000 with more than $10 million in funding from its founding sponsors – the Canadian Foundation for Innovation (CFI), the Ontario Innovation Trust (OIT) and the Ontario Research and Development Challenge Fund (ORDCF) and industry partners – the MMRI provides a focus for high-profile research and serves as a vehicle for university-industry-government interaction. In addition, the institute promotes, encourages, and performs fundamental and applied research in cooperation with its industrial partners and provides systematic mechanisms for technology transfer and infusion of knowledge and research results.

For more information

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McMaster University

MMRI CONNECTION
Connecting University, Industry, and Government — April 2004

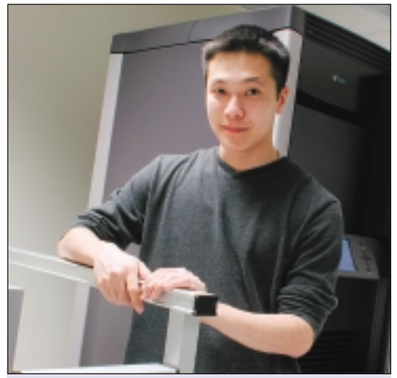
Here come the interns...
A spotlight on Enginering Students gaining experience through research internships at MMRI

Albert Iwasaki, Engineering Physics and Management

My experience at the MMRI as an NSERC summer research student was both challenging and exciting as I was given the opportunity to actively participate in research as opposed to simply assisting. Currently I am in my fourth year studying Engineering Physics and Management and I plan to graduate in the spring of 2005.

Under the supervision of Dr. Philip Koshy, I implemented a code to simulate diamond grinding to predict the roughness and variability of ground surfaces under various conditions. The majority of the compiling of simulation code was done on an SGI® ORIGIN® supercomputer consisting of 32 CPUs operating in parallel. To model the results of a single grinding pass, it was required to perform several million calculations, which was handled quite easily by the computing facilities at the MMRI. Following a thorough analysis of the results from the simulation, I co-authored a paper entitled, "Surface Generation with Engineered Diamond Grinding Wheels: Insights from Simulation," that was published in the 2003 edition of the CIRP Annals, arguably the most prestigious journal in the area of Manufacturing.

Through my experience with the MMRI, I gained a great depth of knowledge in grinding as well as various computer skills. More importantly, the MMRI gave me valuable experience in research, experimentation and problem solving complementing both my academic and career aspirations. If you are seeking both a challenging and fulfilling research or work experience I recommend exploring the MMRI as it offers the opportunity to work with both extremely knowledgeable individuals as well as excellent research facilities. ■



"MMRI gave me valuable experience in research, experimentation and problem solving, complementing both my academic and career aspirations."

Iryna Rex, Chemical Engineering – Polymer Processing Group

I am a graduate student in the Chemical Engineering Department – Polymer Processing Group. After receiving my Bachelor of Engineering (Chemical) in 2002, I enrolled in the M.A.Sc. program that September and will be graduating this summer of 2004.

My decision to continue studies in the area of polymer processing was inspired by the industrial experience I received through completing a 16-month internship at the DuPont Canada Nylon Plant, in Kingston. At DuPont I was exposed to both R & D and manufacturing environments, working in a team with researchers, professional engineers, maintenance personnel, manufacturing operators and electricians on various projects. This experience allowed me to try various types of work

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Here come the interns

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and determine which aspect of the engineering profession interested me the most.

My current project, under the supervision of Dr. M. R. Thompson and in collaboration with Imperial Oil, involves studying the degradation mechanism of High Density Polyethylene in an injection molding machine. Prevention of polymer degradation during processing is a significant challenge to resin suppliers and polymer processors.

A number of studies have been published investigating polymer degradation during extrusion and multi-pass recycling operations. However, little research has been done to look at the low extent of degradation caused by single-pass processing in an extruder or an injection molding machine. The aim of this project is to investigate the effect of operating conditions and antioxidant concentration on polymer degradation during single-pass injection molding.

This project was a great opportunity for me to obtain practical experience operating various types of equipment, such as the 55-tonne injection molding machine and the HAAKE rheomix, along with conducting a vast variety of analytical studies, such as MFI analysis, rheological tests and ATR-FTIR analysis.

The opportunity of working closely with Imperial Oil was a very beneficial experience for me as well. The ongoing communication with the industry provided me with a better understanding of the issues that are presently battled in the industrial environment. The annual meetings with the industrial partners enabled me to obtain experience in effective communication and public speaking. The organized on-site visit I found to be very helpful also, since it presented me with an opportunity to learn about the most recent developments in industry and to observe various types of equipment in operation.

I am very satisfied with the choice that I made to pursue a graduate degree and to be involved with this project. I found it to be a wonderful experience not only from an educational point of view, but also from an industrial and social perspective. ■

"The opportunity of working closely with Imperial Oil was a very beneficial experience for me. The annual meetings with the industrial partners enabled me to obtain experience in effective communication and public speaking."

Jeremy Stenekes, Mechanical Engineering

My experience in the MMRI began as a summer student after my second year of Mechanical Engineering. Through the UROP program (Undergraduate Research Opportunity Program) I received a summer internship where I helped out with a number of projects. The experience I gained and the people I met were incredible. The professors and research staff all have a lot of knowledge that they were happy to share with me. It was also nice to get to know several of my professors on an individual level.

Within the first few months I had been trained to use some of the very expensive and complicated machinery in the Machining Systems Lab (MSL). Another student and I were the first undergrads to use this machinery, so it was a great privilege and a huge responsibility to be given.

Having given a good impression to MMRI staff I was able to come back for a second summer and this time with my own project. The project I was given was to optimize parameters for a new production line at the General Motors St. Catharines' plant. Working under the supervision of Dr. Ng, Research Manager, MSL, I met with General Motors Engineers to discuss the progress Dr. Ng and myself had been making.

"For the first time I knew what it is like to be an Engineer."

For the first time I knew what it is like to be an Engineer. I was at first overwhelmed by the very experienced professionals in our meetings and didn't say much. Dr. Ng really encouraged me to join in and not to feel intimidated when I had a question or an idea. I felt that everyone listened to me and that I was treated as an equal rather that just a summer student. We did a number of experiments being careful to record and properly analyse our findings. Eventually we achieved a solution that was far beyond the original expectations of the project.

Working in the MMRI also far exceeded my own expectations. I feel that I have received a much better picture of what my career may be like than what I have been able to extract from school. This experience has given me motivation and now that I am in my last year of study I plan to stay in the MMRI to work on a masters degree. ■

James Richter, Mechanical Engineering

The moment I knew I was going to apply to mechanical engineering was at a University of Toronto Engineering Open House where they had both Mini-Baja and Formula SAE student project cars on display. Seeing the Mini Baja car run up and down King's College Road, made me realize that this was what I wanted to do. From that day forth I was filled with inspiration and motivation to take on the challenge of university engineering.

"I found my internship at Liburdi Engineering to be extremely rewarding. It allowed me to gain lots of practical knowledge, industry experience and contacts, pay off debts as well as save money for my last year of school."

As a High School Co-op student at General Motors I learned CAD, manufacturing and the assembly line process. Summer 2001 at MMRI I designed a tool fixture, performed metal cutting testing, analyzed results for force and tool wear data, and learned to solid model using CATIA. Machining and welding courses I've taken at Mohawk College have been a huge benefit.

In 2002-2003 Liburdi Engineering offered me a great opportunity to gain "hands on" industry experience through an internship program. At Liburdi Engineering for 15 months on the Aero-Derivative Repair Team I was involved in many projects from start to finish. The main focus of our group was to repair and rejuvenate hot gas section turbine blades for multiple life cycles. Many facility and development projects were also part of my job description.

Developing new fixtures for different types of blades and replacing old designs was a big part of the job. This led to a lot of discussions involving fixture design concepts, engineering to fit the profile of the blade by using CMM and 3D CAD, creating manufacturing drawings, and finally accuracy and repeatability inspections for the fixture. Many of the fixtures I designed were for Wire EDM, Sink EDM and Automated Welding processes to increase production capacity, accuracy and repeatability. Implementing 3D welding chills that match the profile of a turbine blade airfoil, successfully reducing cracking problems, as well as a multi-blade EDM fixture that cut production times in half were some of the key highlights of projects I was involved with. Some of the development projects I was involved with included Downdraft Bench design and fabrication, and Retort Furnace component design, fabrication, and control software design and coding.

My internship at Liburdi Engineering was extremely rewarding. The practical background along with the theoretical is critical to truly understanding a process and helps to quickly solve problems that can arise. These are the skills not easily taught in the classroom, requiring extra curricular efforts. I strongly encourage every student to search out what opportunities exist in and outside of school to get these skills through: internship, summer jobs, Collegiate Design Competitions such as Formula SAE, Continuing Education College courses, etc. These experiences are not only rewarding and exciting to work on, but build a strong resume in the process. Through all the interviews I've been in, the main topic of discussion is your "Practical" or "Hands On" experience. A company is looking for what you have done, and what you can do for them in the future, not necessarily how high your marks are. I found that University provides you with the fundamentals and great problem solving ability, but it is up to the student to get a jump-start on practical training to prepare for industry. With few jobs out there for new grads you really need to be proactive and give yourself a competitive edge, and having an internship on your resume is a great way to do it. ■

Matt Bigger, James Richter, Marco Leone, Julius Bago, Brian Wilson, Rob Varao

James Richter, Formula SAE – Co-Captain, 1999-2002

The Formula SAE competition is a student design competition to build a scaled down "Formula 1" open wheeled racecar that takes place in Detroit, Michigan with over 140 schools from around the world in attendance. McMaster had the opportunity to compete in the European competition, *Formula Student*, held in England 2002 and finished in the top 10 schools internationally.

With limited resources available and tight time schedules it really teaches you to make the most of what you have. Building a car that runs from scratch is not an easy task. Building one that can last for 1/2 hour of tremendously hard driving is an even more difficult task as can be seen in the Endurance event when only 25-30% of the cars finish.

There is a huge learning curve with this program, so much so that the head judge in 2001, the late Carrol Smith, shared a conversation he had with one of the Big Three Automakers. He stated that: "Hiring a new graduate engineer straight out of school, it can be expected to have a 3-year training period to reach their potential. Hiring a new graduate with Formula SAE experience drops that time to 18 months."

I believe that the Formula SAE experience I had played a large part in the internship offer I got from Liburdi and will in future jobs to come, as it showed the experiences I have had and passion for my field of study.