THE CANADIAN SOCIETY FOR MECHANICAL ENGINEERING
LA SOCIÉTÉ CANADIENNE DE GÉNIE MÉCANIQUE
FALL/L'AUTOMNE 2017

BULLETIN

CANADA 150

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FALL/L'AUTOMNE 2017

CONTRIBUTE TO THE

CSME BULLETIN

We welcome submissions of events, announcements, job postings, and feature articles relevant to mechanical engineering from researchers and engineers in Canada.

Please send your input to:
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Editor's Letter

I AM DELIGHTED TO INTRODUCE YOU TO THE FALL 2017 ISSUE OF THE CSME *BULLETIN*. Having the honour of working with Professor Cecile Devaud over the past three issues, it is my pleasure to serve the Society as the editor of CSME *Bulletin*. I would also like to welcome Professor Marc Secanell Gallart, from the University of Alberta, to the CSME *Bulletin* as the associate editor. We hope to bring forward bulletin issues that focus on challenges within and strengths introduced to the field of Mechanical Engineering in Canada.

In this issue, we have celebrated Canada's 150th birthday and how Mechanical Engineering has evolved and will continue to shape our future in Canada. The Honorable Reza Moridi, Minister of Research, Innovation and Science, tells us about Ontario's investment in advanced technologies and the role of mechanical engineers in shaping the future of the province. In this issue, you may also read about the NSERC's strategic plan dubbed "NSERC 2020". I invite you to read the *Chair's Corner* article by Professor William Hallett and a feature article by Professor Andrew H. Wilson that include exciting stories about the history of Mechanical Engineering in Canada. Another feature article will tell you about the University of Alberta's $75 million investment in the energy sector. For the *New Faculty Spotlight Series*, we focus on Western Canada once again, introducing the research areas of Professors Cree and Wiens from the University of Saskatchewan, as well as Professors Hogan and Qureshi from the University of Alberta. This issue's interview is with Professor James Douglas Dale from the University of Alberta. The *ME Research Highlights* were done by Professor Amy Bilton. We are currently seeking another Technical Editor who can help Professor Bilton in the future. Please contact me if you are interested in this role.

We are currently in the process of selecting a theme for the next *Bulletin* issue. I would be glad to hear from you about the topics that are of interest to the Society. In the past, we have focused on research, education, climate change, entrepreneurship and women in engineering. I think we need to have an issue on research funding in Canada at some point. I look forward to hearing from you.

Meanwhile, please enjoy reading this issue.

POUYA REZAI, PhD, P.Eng., MCSME
Editor-in-Chief CSME *Bulletin*
Assistant Professor
Department of Mechanical Engineering
Lassonde School of Engineering
York University

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PHOTO COURTESY OF THE LASSONDE SCHOOL OF ENGINEERING, YORK UNIVERSITY

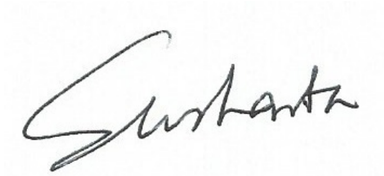
President's Message

Dear CSME Members,

I AM EXCITED ABOUT THIS FALL 2017 ISSUE WHICH CELEBRATES CANADA 150 and showcases how mechanical engineering has shaped our past and creates a stronger future for Canada. For our society, it is indeed an exciting year. We have launched our newly rebranded *CSME-Transactions* through the Canadian Science Publishers and its first issue will appear in January 2018 under the new editor-in-chief, Professor Marius Paraschivoiu (a CSME past-president). There is significant momentum building up as more members contribute to our society by volunteering on technical committees, organizing sessions in our annual CSME Congress, and being part of a vibrant community.

As we were collectively making significant changes to the operation, governance and outreach activities for the CSME, I had a significant change in my own professional life. I moved to the University of Waterloo as the Executive Director for the Waterloo Institute for Nanotechnology (WIN), an exciting challenge and opportunity for me for the next five years. I look forward to welcoming the CSME board for its 29 October meeting at WIN. My sincere thanks to all the volunteers and board members and executives who worked tremendously for last six months to steer the society towards increased success and move it in the direction articulated in the recently announced *CSME Strategic Plan 2017 – 2022*.

Best wishes,



SUSHANTA MITRA, PhD, P.Eng., FCSME, FEIC, FCAE, FAAAS
CSME President
Professor, Mechanical and Mechatronics Engineering, University of Waterloo
Executive Director, Waterloo Institute for Nanotechnology

Message du président

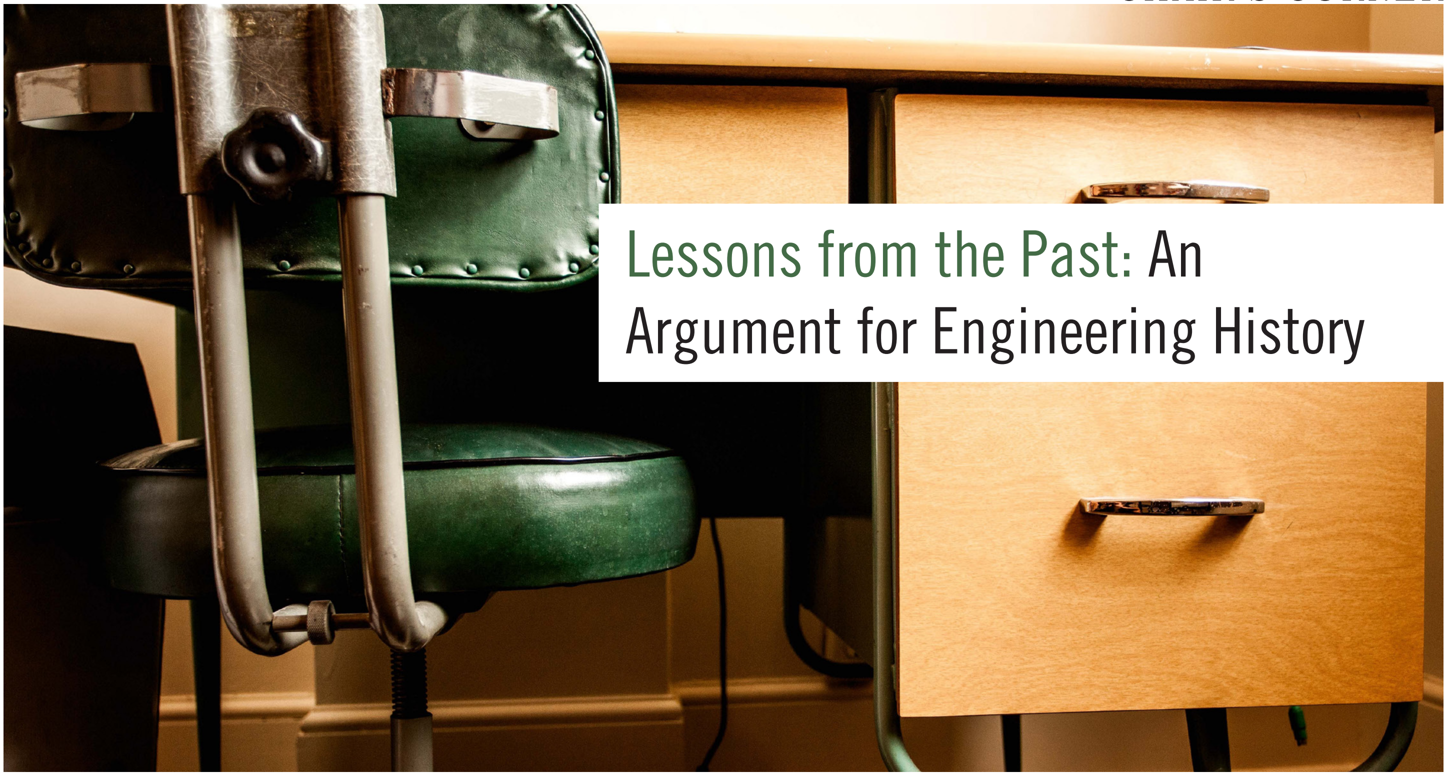
Chers membres de la SCGM,

Je suis ravi de cette édition automne 2017 du Bulletin qui célèbre le Canada 150 et illustre à quel point l'ingénierie mécanique a façonné notre passé et crée un avenir plus fort pour le Canada. Pour notre société, ce fut vraiment une année passionnante. Nous avons relancé le journal *Transactions de la SCGM* à travers « Canadian Science Publishing » et son premier numéro apparaîtra en janvier 2018 sous la nouvelle rédaction en chef, le professeur Marius Paraschivoiu (un ancien président de la SCGM). Il y a un nouvel élan fort créé par les membres qui contribuent à notre société en faisant du bénévolat sur les comités techniques, en organisant des sessions du Congrès annuel de SCGM et en faisant partie d'une communauté dynamique.

Comme nous étions collectivement en train de rehausser les activités de fonctionnement, de gouvernance et de sensibilisation pour la SCGM, j'ai vécu un changement important dans ma propre vie professionnelle. J'ai déménagé à l'Université de Waterloo pour prendre le poste de directeur exécutif de l'Institut Waterloo sur la nanotechnologie (WIN), un défi et une opportunité intéressants pour les cinq prochaines années. Je planifie y accueillir le conseil d'administration de la SCGM pour sa réunion du 29 Octobre. Je remercie sincèrement tous les bénévoles et les membres du conseil et dirigeants qui ont travaillé énormément pendant les six derniers mois afin d'orienter la société vers un succès accru et la direction énoncée dans le plan stratégique 2017-2022 récemment annoncé.

Sincères salutations,

Président



Lessons from the Past: An Argument for Engineering History

DR. **WILLIAM HALLETT**, Dr.-Ing., P.Eng.

Dr. Hallett is a Professor in the Department of Mechanical Engineering, University of Ottawa, and was Department Chair from 1997 - 2009. After completing bachelor's and master's degrees at the University of Waterloo he earned a Dr.-Ing. from the Universität Karlsruhe in Germany in 1981 and joined the University of Ottawa immediately thereafter. He is the recipient of several teaching awards, including an OCUFA Award (1989) and a 3M Fellowship (1994). His research field is solid and liquid fuel combustion.

IT MAY SEEM STRANGE TO SUGGEST that a forward-looking discipline like mechanical engineering should also be interested in the past. Yet there is much to be learned from our history that can inform the present, and in some cases history may save us from re-inventing the wheel.

I write this as the semi-official historian of the University of Ottawa's Faculty of Engineering, having written the official history of engineering programs at Ottawa for our Faculty's 25th anniversary celebrations in 2011 [1]. Engineering at Ottawa actually goes back much further, all the way to the start of our first civil engineering program in 1873 and progressing through the re-establishment of engineering programs in 1946. Researching this was a fascinating journey into the past and the almost-forgotten culture of a 19th century church-run University. One can learn a great deal about leadership and self-sacrifice from the Oblate priests who ran the University of Ottawa from its inception in 1848 until its secularization in 1965. The old documents show that these people had a clarity of vision and mission that is difficult to find in universities today: for example, the motivation for the civil engineering program in 1873 was the simple statement that "Le génie civil...est... un service rendu à la religion et au pays..." [2]. They received no government funding, yet they established high quality programs and built the foundation for our present day successes with an absolute minimum of resources.

Of course, we would certainly find some of the old academic rules confining today. Until the 1960's universities were expected to act much more *in loco parentis* than now, and the 19th century Ottawa calendars accordingly banned smoking, profanity, and "irreligious or otherwise pernicious works" – but are our students better off for having "recreational" drugs and a universe of other distractions at their fingertips? The regime had lighted considerably by the 1940's, but even then the calendar warned that "Students whose conduct or lack of application is deemed prejudicial ... may be dismissed" [3], and students could be fined a dollar for each lecture missed. How many times have you wished that you could do something about students with a "lack of application" in your classes? And the rule in the Ottawa calendars up till the late 1960's requiring the wearing of jackets and ties in lectures might help even today to instill a more professional culture into what is supposed to be preparation for a professional career.

One often hears the claim that an engineering education is out of date 5 or 10 years after graduation. But old calendars, curricula and textbooks show that this is largely untrue, because most of what is taught in a present-day curriculum is in fact fundamentals which never go out of date. The basic thought processes of force, mass and energy balances are as important as ever, even if the tools we use to solve them have changed. We can take, for example, Ottawa's mechanical engineering curriculum: *all* of the core courses in our current program have direct counterparts in the courses of 1968 [4]. The chief differences in the old program are more natural sciences content and less design than today (the current accreditation regime began in 1967). And this should not be surprising: most of mechanical engineering is based on a small number of physical principles, such as Newton's Laws, the laws of thermodynamics, and basic concepts in strength of materials. Textbooks from the past differ from current ones mainly in the graphical presentation; the old ones sometimes appear rather dry to modern eyes, but they are often more rigorous, and some contain material that is pedagogically excellent. (They also generally exhibit a much higher standard of English composition than today, but that is another matter!) I've often enjoyed going through them and extracting material that I can use for my own classes.

Complementary studies have always been a part of the engineering curriculum, to judge from Ottawa's offerings. The 1874 Ottawa Civil Engineering program includes courses in moral philosophy (ethics, in other words), society and "political economy" [5], while the 1968 program has courses in ethics, economics and law plus English and French. The 1940's program even includes a workshop course of four hours per week. Wouldn't that be a good experience for students whose lives are otherwise lived entirely within their cellphones?

One of the lessons of history is that few challenges and innovations are truly new. Solar thermal power? Already done in the late 19th century. Flying cars? Check *Popular Mechanics* of 50-60 years ago, where you will also learn that gas turbine cars are the way of the future. Environmental considerations are causing the refrigeration industry to return to 19th century working fluids such as carbon dioxide and ammonia [6]. Today's automatic transmissions are similar in principle to the planetary gearboxes of Ford Model T's a century ago. Pratt and Whitney's geared turbofan engine has effectively re-invented the turboprop. Battery-driven electric vehicles were used more than a century ago, and even found some applications on railways. Finding new sources of energy has always been a problem: 150 years ago wood, the staple fuel of pioneer Canadian industries, became scarcer and gave way to coal. Railways are coming back into their own as their potential as the most green of all transportation modes is recognized.

Another lesson of history is that our ancestors were extremely innovative and resourceful people. An example that I regularly share with my classes is a group of steam locomotives that the Canadian Pacific Railway built in 1899 for high speed service between Ottawa and Montreal. I enjoy asking the class what they thought "high-speed" meant in 1899: they are astonished when I tell them that these machines were designed to run at 80 mph (130 kph) and permitted downtown-to-downtown service in 2 1/2 hours – the same time as VIA Rail or the highway today. They are even more amazed when they learn that the time from the start of design to the successful test of the first machine was nine weeks (1 May - 3 July 1899) [7]! Could any modern organization design and build anything as large and complex as this in such a short time, despite the much wider range of engineering and management tools available to us today?

Historical lab equipment can also offer an immediate connection with the real physical world that is not present in experiments whose measurements are automated by a data acquisition system. I envy one Canadian mechanical engineering department that still uses a 1910 vintage reciprocating steam engine with a mechanical indicator for undergraduate labs: the processes occurring there are physically present for students in a way that they can never be in a computer display from a typical modern lab Diesel engine, and the additional effort that students must put into understanding the process and doing the calculations is of real pedagogical value.

Even in research, a knowledge of history in the form of the classic literature in the field is valuable. The older of us, whose knowledge of the literature goes back 40-50 years, will often have had the experience of reviewing a paper whose foundations are inadequate because the literature search only goes back a decade or so. (At the opposite end of the spectrum, I once used experimental data from 1916 to test a model!) Or you may have come across numerical calculations presented by people who are unaware that there is an analytical solution to the problem. Many papers that I review show a superficial approach to methods or to the interpretation of results, often due to lack of knowledge of the fundamental principles laid down in the older literature. Moreover, what makes many older papers classics is that their authors waited until they had enough material for one or two seminal papers rather than dissipating their work into a dozen papers of incremental steps. Unfortunately, literary diarrhea has become the norm in academic publishing.

In conclusion, I would encourage those of you who do not know the history of your own institution or discipline to dig into it, and to preserve its landmarks. Plus ça change, plus c'est la même chose!

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PHOTO: SHUTTERSTOCK [ID: 196509659]

Canada 150 and Mechanical Engineering

A very brief review

MECHANICAL ENGINEERING WAS 'DONE' in Canada in the decades before the Confederation of the three provinces by a very few professional engineers and by many more machinists, millwrights, mechanics and blacksmiths. By 1867 they were building steam engines for stationary and shipping applications, as well as agricultural, construction and mining equipment, locomotives for the railways, and ocean- and lake-going ships. Water-powered saw, grist and other mills were also being built. With time, the leaders and entrepreneurs in the field were adding to the number of professionals. Formal education in civil engineering began in the 1850s but, for the mechanical variety, had to wait for another two decades.

ANDREW (DREW) H. WILSON IN FRONT OF THE CANADIAN PACIFIC LOCOMOTIVE 1095, NOW DISPLAYED IN FRONT OF THE CITY HALL IN KINGSTON. IT WAS BUILT OVER 100 YEARS AGO BY THE CANADIAN LOCOMOTIVE COMPANY IN KINGSTON, ONTARIO.

PHOTO CREDIT: ROD TRIDER

Throughout its history in Canada since 1867, mechanical engineering activity has often stood by itself. But it has also been part of engineering projects involving other disciplines – for example, along with civil and electrical engineering in the construction and operation of hydroelectric plants, in the various transportation modes, and in mining.

Between 1867 and the end of World War I, Canadian mechanical engineering moved from being basic and rural to acquiring the technical competence of a more advanced nation. The federal government's national policy helped generate manufacturing activity, added to which were the development of western agriculture, hydroelectric generation, the pulp and paper industry, street car systems and waterworks. In machine shops, for example, the power sources for machine tools changed from steam-engine/belt-drive systems to electrical drives. The circumstances of the War and the temporary end to European influence also played their part. And, although there were steel shortages for some mechanical products, Canada plants produced munitions on a large scale.

By World War I, there were five university-level institutions in Canada offering degrees in mechanical engineering.

The years between 1919 and 1929 brought activity to mechanical engineering, and especially in the primary industries, transportation, construction and agriculture. The influence of the decade of the Depression was negative, but engineering activity did not disappear completely. Experimental work continued at Baddeck on hydrofoils, and Turnbull perfected his variable pitch propeller. Work was done, for example, on adapting small aircraft to use floats and skis so that they could contribute to the opening up of the north, as well as on the development of vehicles for use in snow. The Hudson's Bay and Kettle Valley Railways were completed. The Island Falls hydro plant was built in Saskatchewan. The first self-propeller combine harvester was developed for Massey-Harris. At the provincial level, the Ontario Research Foundation was established, to be followed later by similar facilities in other provinces.

World War II contributed even more to the development of Canadian mechanical engineering than did the first War, and especially in regard to the building of large numbers of aircraft and ships. As before, ammunition was manufactured in large quantities. A number of organizations, such as Turbo Research, Victory Aircraft and the Polymer Company, were established to meet specific wartime objectives. The NRC was deeply involved in wartime research. The Shipshaw hydroelectric plant was built on the Saguenay River to provide power for the enlarged aluminum plant at Arvida, Quebec.

Mechanical engineering in Canada received a significant boost in the immediate postwar years when thousands of veterans enrolled in university degree courses. Aided by immigration, this new blood added both volume and expertise to mechanical engineering activities over the years since 1945.

Since 1945, more than two-dozen academic institutions across the country have offered degree courses in mechanical engineering, most with post-graduate studies as well. But, today, the engineering student is no longer distinguishable from any other. The once ever-present slide rule has been replaced by pocket calculators and personal computers. And, especially since the 1960s, faculty members in the departments of mechanical engineering have acquired extensive research support, notably from the NRC and NSERC. At the provincial level, also, educational support for mechanical technologists and technicians has increased significantly.

Canadian engineers have been making significant contributions to the engineering of space vehicles and their equipment – the STEM antennae and the *Canadarms*, for example – and to the peaceful uses of nuclear energy, by way of the *Candu* reactor systems. There have been contributions to aviation, although these have not always been successful commercially. The manufacturing sector has grown, although in recent years some long-established companies have gone out of business for a variety of reasons, or have changed from domestic to foreign ownership.

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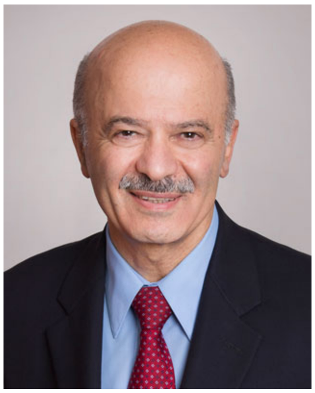
Harnessing the Spirit of Past Generations



Hon. Reza Moridi, MPP
Minister of Research, Innovation and Science
Government of Ontario

Canada was built on foundation of global industrial and economic change. Previous generations faced daunting challenges as they established the agricultural, industrial and transportation networks that form the core of our communities. They had to embrace new technologies, new tools and new ways of working. In doing so, they laid the groundwork to advance the greatest period of global economic growth in human history.

Mechanical engineering has played a central role in Ontario's historical economic-technological revolution. Creative and innovative mechanical engineers led the design, marketing and manufacturing of entire systems of production in nation-building sectors like agriculture, forestry, mining and transportation. These technologies evolved alongside our education system, giving rise to Ontario's dominance in modern sectors like automotive, aerospace, energy, manufacturing, biotechnology, and information and communications technology.

In the last few decades, the world has seen a rapid acceleration in the advancement of new technologies. In fact, most experts agree that we are in the midst of another global technological revolution. Technologies like artificial intelligence, 3D printing and robotics are now reshaping our lives. Such advancements are all-encompassing, which is why mechanical engineers cannot operate in a vacuum. Cyber physical systems are a pervasive part of our society, and are operating in transportation (automated vehicles), health care (tele-surgery), manufacturing (industrial automation) and the hospitality sector (service robots).

These transformative technologies have the power to unlock solutions to some of society's biggest problems — from reducing climate change to curing diseases to feeding the hungry. Transformative technologies also have the potential to shift not just what we're working on, but the way we work and how we define work.

The convergence of mechanical engineers with other disciplines is where the most interesting — and arguably the most disruptive — advances will occur. From advances in space tourism to new machinery based on quantum technology to new carbon-reducing infrastructure, there are an unpredictable number of cases where mechanical engineers will play critical roles in advancing society.

In Ontario, the government has been closely studying transformative technologies. We have already established a footprint in areas such as:

- artificial intelligence, which allows computers to perform intellectual tasks without human supervision or intervention
- genomics, which enables customized, faster and cheaper solutions to predict and cure diseases, increase crop yields and improve food safety
- the Internet of Things, which improves efficiency and accuracy in areas like manufacturing, transportation and infrastructure arrangement
- clean technology, or the sustainable and efficient use of energy and resources
- advanced computing, fintech and cybersecurity
- advanced materials, widely applied in industries from automotive to health care
- advanced robotics, which can execute tasks on their own and create a safer environment for human workers
- autonomous vehicles; and
- Next Generation Networks (NGN), the foundational infrastructure that will allow us to manage the exponential growth of data and seamlessly communicate with billions of connected devices.

And we continue to make important investments in transformative technologies that could impact industries like health care, finance, education, energy, transportation, advanced manufacturing and ICT, such as:

- $130 million into 5G and next-generation networks
- $80 million into the Autonomous Vehicle Innovation Network
- $50 million into the Vector Institute for Artificial Intelligence
- $50 million into the Perimeter Institute
- $20 million into Quantum Valley Ideas Labs
- $4 million into the Cybersecurity Fintech
- Innovation Pilot Program.

These are important investments in Ontario's future, but they cannot stand alone.

Through various regional funding programs, we partner with businesses and non-profits to aid in job creation, enhanced productivity and scaling-up to global markets. Initiatives like the Ontario Basic Income Pilot program and inclusive labour reforms in our proposed Fair Workplaces and Better Jobs Act are aimed at mitigating the impact of transformative technologies on precarious workers and workers of varying skill levels. We are providing all Ontarians access to high-quality post-secondary education and skills training through programs like Ontario's Highly Skilled Workforce Strategy and Second Career. At the same time, we are working to foster a competitive business environment through business taxation reform and initiatives like the Red Tape Challenge, while still protecting environmental and health standards and enhancing worker safety.

We know that Ontarians are concerned with how rapid technological advancements are impacting their lives and their communities. We are all worried about job security, privacy, ethics, and just keeping up with the pace of change.

In these uncertain times, it's important to reflect back on and the generations that built this nation and this province over more than 150 years. They too were concerned about the future of their families and their communities. Our history, our values and our identity as Canadians and Ontarians are on our side: today's new technologies are just the latest wave in a constant tide of change that began a long time ago.

Transformative technologies can cause uncertainty and upheaval, but they can also be empowering and progressive. Ontario's readiness to adopt new technologies has always been a driver of our success. It is what gives us the financial freedom to pay for the social programs we care deeply about.

Although the work you do as mechanical engineers might look radically different 15 years from now, I know that you have the skills, education and determination to meet these challenges head-on. Here in Ontario, we recognize the crucial role that you and future generations of mechanical engineers will play in shaping this province's future. Working together, we can harness the positive power of transformative technologies and reap the rewards of a healthy, secure and prosperous new Ontario.

STUDENTS AND RESEARCHERS AT WORK ON ULTRA-LOW TEMPERATURE DIFFERENTIAL ENGINES, ELECTROLYZERS AND FLYWHEEL TECHNOLOGIES.

University of Alberta: $75-million Future Energy Systems program provides unique opportunities for researchers and students

Dr. **LARRY KOSTIUK**, FCSME*, is the Director of Future Energy Systems at the University of Alberta. A Professor of Mechanical Engineering, he has served as Associate-Vice President (Research) since 2015, and was previously the Chair of the University of Alberta's Department of Mechanical Engineering. After receiving his BSc in Mechanical Engineering from the University of Calgary, Larry completed his MSc at the University of Alberta, and his PhD from Cambridge University. He completed his Postdoctoral Fellowship at the Lawrence Berkeley National Laboratory in California before returning to the University of Alberta in 1993.*

IT IS A TRULY EXCITING TIME for energy research around the world. Stories about new energy technologies are capturing our collective imaginations, and though many claims publicized through social media cannot yet be realized, the enthusiasm shared by millions of people signals the arrival of a new era of energy technology development. Researchers have been working towards this era for many years, but thanks to growing public awareness and political will, new opportunities are appearing.

This year, the University of Alberta launched Future Energy Systems, a $75-million research program funded through the Government of Canada's Canada First Research Excellence Fund (CFREF). Over seven years, this program will support dozens of research projects, as many as 100 principal investigators, and up to 1,000 highly qualified personnel (HQP). It will also establish and advance industrial and international research partnerships.

Future Energy Systems is developing energy technologies of the near future, examining their integration into current infrastructure, and considering their social, economic, and environmental impacts. We will also contribute to novel approaches and solutions for the challenges presented by existing energy technologies. Our focus is on the supply-side of energy (less so on usage or efficiency), but our objective is to address questions relevant to the entire energy generation narrative – from the instant energy is captured to the moment it is utilized.

At present, we have launched more than 40 projects across 14 themes: biomass; carbon capture, storage and utilization; communities and aboriginal; energy humanities; geothermal; grids and storage; heavy oil – in situ; heavy oil – non-aqueous recovery; heavy oil – partial upgrading; land and water; non-electric infrastructure; solar; system-wide; and wind.

Because we consider questions related to both harnessing energy and its integration into our society, Future Energy Systems engages a multidisciplinary group of researchers. Our Principal Investigators and their teams include mechanical, chemical, civil, environmental, and systems engineers, as well as scientists, economists, humanities scholars and social scientists.

Within this framework, we are able to offer two unique research advantages. First, our projects receive stable funding for up to seven years (with annual reviews to ensure they are meeting objectives and milestones set by researchers in proposing the work). Second, our researchers have the chance to collaborate closely with colleagues across the institution, as well as industrial partners, and academics from the University of Calgary and the Northern Alberta Institute of Technology.

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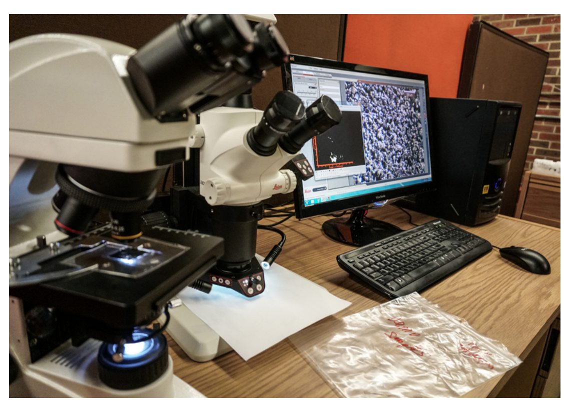


PHOTOS COURTESY OF FUTURE ENERGY SYSTEMS

Generations of mechanical engineers and researchers have benefited from NSERC's many investment programs. NSERC is proud to have backed Canada's top minds in mechanical engineering research throughout their careers. These NSERC-trained and supported engineers have become leaders in their fields by pursuing high-impact research. NSERC continues to support Canadian research in mechanical engineering to help address some of the world's most important issues and to ensure continued training opportunities for the next generation of engineering talent.

"The evidence is clear; we are in the midst of the fourth Industrial Revolution. It's being driven by the confluence of the digital, biological and physical and is coming at a time when society is facing some of our biggest challenges, such as food and clean water for all, healthy mothers and babies, and a clean planet. Many new disruptive technologies will arise, and members of the natural sciences and engineering will fill a key role in driving disruptive innovation for societal benefit. As a community, research and exploration also provides a fertile environment for training and development of a new generation of talent for Canada in the 21st century."

Dr. B. Mario Pinto
President, NSERC

CLEAN, SUSTAINABLE AND ALTERNATIVE ENERGY

Climate change is one of the most important issues facing us today, and the emission of greenhouse gases is a key contributing factor to global warming. Mechanical engineering advances in sustainable and clean-energy systems lead not only to finding alternatives to energy sources that increase atmospheric greenhouse gases, but also to developing systems for generating, storing clean energy and reducing energy consumption in buildings.

BIOMECHANICS AND BIOMEDICAL TECHNOLOGIES

The economic and societal burden of musculoskeletal injuries and diseases (e.g., arthritis) is expected to increase in Canada. Biomechanical engineers contribute to improving outcomes and quality of life for individuals with these conditions. Research in this area includes the design and improvement of medical devices such as implants, prostheses, robotics for medical applications and other assistive and rehabilitative devices.

AUTOMOTIVE ENGINEERING

Automotive companies are spending billions of dollars to create the next generation of autonomous vehicles. Automated model and controller generation, fueled by advances in artificial intelligence, leads to a huge reduction in time required to develop and launch new products.

NSERC 2020

NSERC's strategic plan, dubbed "NSERC 2020," is guiding the way we do business and is helping us set priorities. NSERC's strategic plan has five goals:

- Foster a science and engineering culture in Canada
- Enable early-career scientists to launch independent research careers
- Build a diversified and competitive research base
- Strengthen the dynamic between discovery and innovation
- Go global: secure access to global scientific and engineering knowledge and expertise and increase participation in international research endeavours

Going forward, a suite of new measures will affect researchers in mechanical engineering:

- We are supporting early-career researchers with a range of initiatives that help get their careers off on the right foot.
- We are implementing the Framework on Equity, Diversity and Inclusion to increase equity in all of NSERC's programs and awards.
- We are improving access to paid parental leave for grant-funded students and fellows.

NSERC-CRSNG.GC.CA

"NSERC support has been critical to my academic success; they provided me with the funding required to hire outstanding graduate students and pursue new lines of research, both curiosity-driven and with industry partners. My NSERC Discovery Grants and Industrial Research Chair funded a critical mass of researchers to develop new methods for model-based dynamics and control that have been commercialized and disseminated worldwide."

Dr. John McPhee
University of Waterloo

"My career wouldn't have been possible without the support of NSERC. I received $130,000 in NSERC scholarships and fellowships which allowed me to further my education and prepared me for a career in academia. I have supervised 50 graduate and postdoctoral students – all have benefited from NSERC funding. These HQP are the ones who will address the great challenges facing us."

Dr. Carey Simonson
University of Saskatchewan

"The moment that one of my undergraduate professors asked me to apply for NSERC's Undergraduate Student Research Award was a pivotal point in my life. Before that moment, I had never considered research as a career option. Over the years, I've had opportunities to meet researchers from around the world, and I can say with confidence that the opportunity and support that I have received to develop as a researcher in Canada are unparalleled, and NSERC grants have been a core part of it."

Dr. Aimy Bazylak
University of Toronto

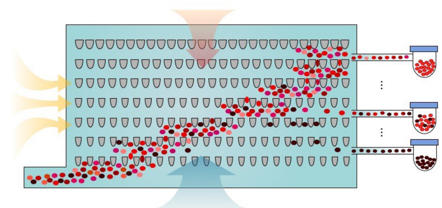
HIGHLIGHTS

New Rapid Tests for E. coli

Currently, when remote areas want to test water samples for E. coli contamination, the test can take several days and cost up to $70. A team of researchers from the University of Waterloo, consisting of **Naga Gunda**, **Sauyadeb Dasgupta**, and Professor **Sushanta Mitra** have developed a simpler, faster, and more cost effective solution. Their innovation consists of a litmus paper tests which detects E. coli through an enzymatic reaction on a porous paper substrate. When immersed in a water sample, the custom engineered surface attracts the E. coli in the water sample, which are then wicked to the reaction zone. In the reaction zone, the E. coli reacts with custom reagents to produce a pink color. Current tests can produce results in between 30 and 180 minutes depending on E. coli contamination levels. The ability to quickly and accurately test for E. coli could have significant impact on remote areas in Canada and elsewhere in the world. Currently, the research is being commercialized through the start-up company Glacierclean. The company hopes to take the technology to market in the next nine months. — *Technical Editor, Professor Amy Bilton*

N. S. K. GUNDA, S. DASGUPTA, AND S. K. MITRA, "DIPTEST: A LITMUS TEST FOR E. COLI DETECTION IN WATER," *PLOS ONE,* SEPTEMBER 6, 2017.

SORTING RED BLOOD CELLS TO IMPROVE MALARIA TESTING



In patients with malaria caused by the parasite, *Plasmodium falciparum*, the deformability of red blood cells is progressively reduced due to parasitic invasion and its associated biochemical processes. In recent work, a research team at the University of British Columbia, led by **Hongshen Ma**, developed a microfluidic approach to separate these infected red blood cells based on their reduced deformability. The microfluidic device sorts red blood cells using ratchet transport through micrometer-scale constrictions. The device has been able to concentrate infected red blood cells, which dramatically improve the sensitivity of detection using microscopy and rapid diagnostic test.

Dr. Ma's group is currently utilizing this approach to expedite the development of new antimalarial drugs, "We are currently modifying this device to sort infected red blood cells based on deformability in order to isolate parasites that have develop drug-resistance. *Plasmodium falciparum* parasites develop resistance easily. Being able to isolate drug resistant parasites is essential for developing new drugs and understanding their mechanisms of action." – *Technical Editor, Professor Amy Bilton*

Q. GAO, S. P. DUFFY, K. MATTHEWS, X. DEN, A. T. SANTOSO, E. ISLAMZADA, AND H. MA, "DEFORMABILITY BASED SORTING OF RED BLOOD CELLS IMPROVES DIAGNOSTIC SENSITIVITY FOR MALARIA CAUSED BY PLASMODIUM FALCIPARUM," LAB ON A CHIP, 16, 645, 2017.

MATTHEW GRANT, MEDIA RELATIONS, UNIVERSITY OF WATERLOO / ILLUSTRATION COURTESY OF THE RESEARCHERS

NEW FACULTY SPOTLIGHT SERIES:

FOCUS ON WESTERN CANADA

This series highlights some new Canadian ME faculty members by region. In this issue, we continue our focus on the Western provinces with research highlights from: Dr. Duncan Cree and Dr. Travis Wiens, University of Saskatchewan, and Dr. James Hogan and Dr. Ahmed Qureshi, University of Alberta.

University of Saskatchewan Dr. **Duncan Cree**

Building with eggshells, a sustainable approach

Dr. **DUNCAN CREE**, PhD, MCSME

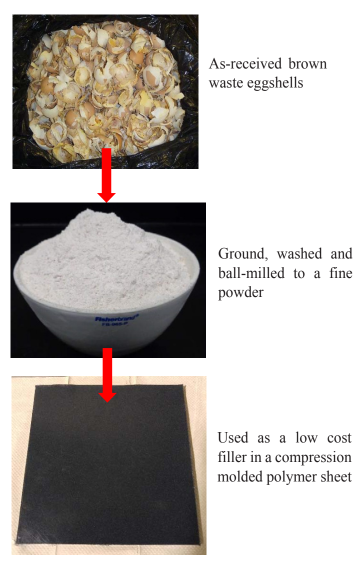
Dr. Cree obtained his PhD in Mechanical Engineering from Concordia University in 2009. His research focused on the production and characterization of a three-dimensional cellular metal-filled ceramic composite for use in electronic packaging materials. From 2009-2011 he was awarded an NSERC Post-Doctoral Fellowship to work in the Civil Engineering department at Queen's University, Kingston, ON. The research involved studying mechanical properties of composite materials at elevated (fire) temperatures which are used in the construction and building industries. From 2011-2014 he obtain a three year contract as an assistant professor in the Civil Engineering department at Queen's University. During this time he was also the Founding Director of Aboriginal Access to Engineering where he was instrumental in the initial development of the program. Dr. Cree joined the College of Engineering's Mechanical Engineering department of the University of Saskatchewan, in 2014 as an assistant professor. His research focuses on sustainable bio-resin composites.

Attention has been growing globally on the need for new materials that reduce the impact on the environment. Bio-materials have been researched for the past decade to address the need for protecting and preserving our environment for future generations. Dr. Cree's research consists of characterizing novel bio-composites produced from sustainable materials. Interestingly, composite material components/ingredients can be tailored for specific applications. They possess a high level of customizability based on the variety of fibers and resin materials used to manufacture the composite. Natural fiber (e.g. flax, hemp) composites along with bio-based resins (a portion of the petroleum resin is replaced with a biomass such as soybean, pine and castor oils) could be a step forward to greener materials. Incorporating fully bio-based thermoset and thermoplastic resins to produce polymer composites are new and innovative avenues of research. However, there is one major drawback which prevents widespread use of natural fiber composites in building applications, which is their water absorption and poor resistance to high temperatures.

The goal of the current work is to understand how chemically treated unidirectional flax fibers with acetic anhydride can improve flax fiber composite strength, fiber hydrophobicity and its compatibility with the bio-resin. Natural fiber composites are also susceptible to fire, however insufficient and inadequate information is available regarding the performance of natural fiber composite materials in fire, especially when novel materials are used in its construction. The aim of this research is to gain a better understanding of how fire retardant additives affect the bio-resin and the overall composite material at both room temperature (20°C) and elevated temperature (150°C). These composites could be used in areas such as: roof shingles, sandwich panel skins, container walls and access door construction.

Addressing the challenges of sustainability using wastes as resources is another area of research Dr. Cree's has interest in. For example, considerable waste of eggshells occurs in the egg processing industries, specifically from egg breaking plants. As an alternative to landfills and disposal costs, eggshells could be recuperated for use as partial or total replacements of natural mined limestone for unique applications. A crushing, grinding and heat-treatment method was developed as an effective way to remove the thin organic membrane surrounding the eggshell prior to implementing as a filler material in thermoset and thermoplastic composites.

Besides research, Dr. Cree is passionate about supporting and promoting higher educational studies to Indigenous students. Less than 1 per cent of Professional Engineers in Canada are Indigenous. Recruitment of undergraduate and graduate Indigenous students is at the top of his list. Ultimately there are a number of issues which still remain to be solved at the elementary and high school levels for students to become excited about math and science. One of his personal goals is to help increase and promote engineering as a career choice to all indigenous peoples with the help of the Indigenous Peoples Initiatives at the College of Engineering. Young Indigenous students need to realize that math and science are not a new field of learning. Their ancestors have used science (in a different way) to find technical solutions to their problems for thousands of years. Indigenous peoples of Canada were very adaptable as can be displayed by the diverse shelters, tools and technologies that were developed according to their environment



ADDITION OF SUSTAINABLE CALCIUM CARBONATE FILLER IN POLYMER COMPOSITES.

University of Saskatchewan
Dr. **Travis Wiens**

The New Priority in Fuel Efficiency: Mobile Hydraulic Equipment

Dr. **TRAVIS WIENS**, PhD, P.Eng.

Dr. Wiens performed his graduate work at the University of Saskatchewan in the field of fluid power and nonlinear controls. He spent two years as a postdoctoral fellow at the University of Auckland, performing wave propagation studies, before returning to Canada to work as a consultant to the fluid power industry. In this role, his major work was to improve the energy efficiency and performance of mobile equipment such as construction, forestry and mining machines. Dr. Wiens returned to academia in 2014, taking an Assistant Professor appointment and assuming leadership of the University of Saskatchewan Fluid Power Laboratory.

How machinery moves has been a focus of Dr. Wiens' interests since his youth, spent operating farm equipment on a Saskatchewan family farm. "I was always interested in how power flowed through a machine like a combine, from the fuel tank, through the engine and distributed via belts, gears and hydraulics to where it did the work. I was also fascinated with how experienced operators could sense just how to run the machine so that all the parts were working well".

A recent study by the US Department of Energy found that the mobile fluid power machinery industry in the US had an average energy efficiency of only 21%, wasting the equivalent of 10 billion liters of diesel fuel annually, and proportionate numbers can be expected in Canada. This is therefore an area where Dr. Wiens believes considerable strides can be made to reduce fossil fuel consumption and exhaust emissions. To this end, his growing research group is conducting studies to improve system efficiency of hydraulic circuits, with projects focused on both short- and long-term improvements.

One short-term project involves changing hydraulic system architecture to both reduce energy losses and recover energy when braking or lowering a load. "Conventional hydraulic systems use throttling valves to control the load. This is very inefficient as the pressure energy is lost," explains Dr. Wiens. "Instead we are developing a pump-controlled system that is much more efficient than the best conventional systems, yet achieves the same high force density and low cost." This system uses conventional components, so can be applied to today's equipment with minimal component design costs.

A more forward-looking project is to study and optimize how human operators interact with machines to improve fuel efficiency. Dr. Wiens says, "I spent a lot of time as a consultant trying to optimize hardware on construction equipment to gain a 5-10% efficiency improvement, but when we tested it in the field, the efficiency would vary by 30% depending on the operator. Other studies have shown similar results with poor operators using up to three times more fuel to do the same job." Dr. Wiens and his team are studying how to help novice operators behave like the best operators and how to make experienced operators perform more consistently. This may take the form of more feedback to the operator about when and how they are wasting energy, and also designing equipment to be more forgiving of operator variability.

Another longer-term project is to help speed the adoption of Switched Inertance Hydraulic Converters, devices use the inertia of flowing fluid to control hydraulic pressure and flow without throttling losses. These devices are the hydraulic equivalent of the switched mode power supply, which are ubiquitous in the electrical world, having revolutionized the efficiency of power supplies in phone chargers, electric vehicles and industrial applications. However, a number of issues have prevented their adoption in the hydraulic domain. One is the slow switching speed of hydraulic valves, when compared to high-speed transistors. Dr. Wiens' group, in cooperation with a major equipment manufacturer, is studying how pressure waves propagate through the long pipelines in these devices, and are exploiting reflected pressure waves to mitigate the slow speed of today's valves. "Switched Inertance Hydraulic Converters show great promise to improve hydraulic system efficiency in the next generation of mobile equipment, and we expect wave propagation effects to be critical to improving their performance to the point where there will be widespread adoption."

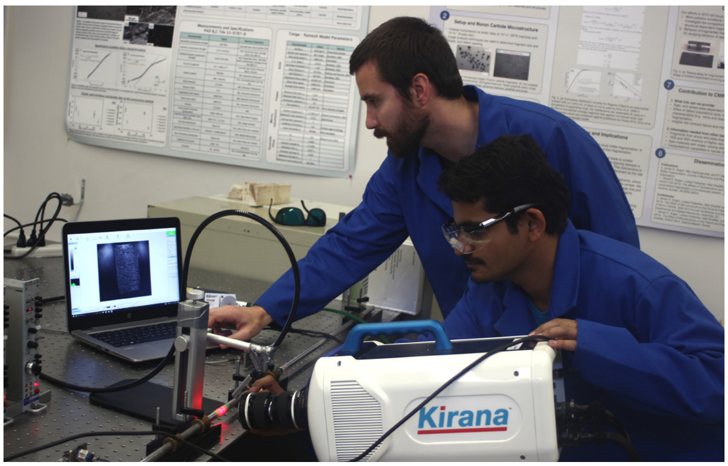
RIGHT:
THE UNIVERSITY OF SASKATCHEWAN FLUID POWER LAB HAS A STRONG TRAINING FOCUS. HERE, UNDERGRADUATE STUDENTS WORK ON A HANDS-ON LAB PERIOD, AS PART OF DR. WIENS' 4TH YEAR DESIGN ELECTIVE "DESIGN OF FLUID POWER CIRCUITS", THE ONLY SUCH UNDERGRADUATE ENGINEERING CLASS IN CANADA.

PHOTOS COURTESY OF DR. WIENS

University of Alberta
Dr. **James Hogan**

Multi-Scale Mechanics of Defense Materials

DR. JAMES HOGAN AND PhD STUDENT KAPIL BHARADWAJ ALIGN AN ULTRA-HIGH-SPEED CAMERA FOR A DYNAMIC COMPRESSION EXPERIMENTAL SETUP.



Dr. **JAMES HOGAN**, PhD

Dr. Hogan joined the Department of Mechanical Engineering at the University of Alberta as Assistant Professor in July 2015. He received his PhD from the University of New Brunswick in May 2013 where, in collaboration with the French-German Research Institute of Saint-Louis, France, he studied the dynamic failure of rocks for Planetary Science and Defense applications. He continued his research on brittle materials for defense applications as a Postdoctoral Fellow at the Johns Hopkins University, in collaboration with the US Army Research Laboratory and Applied Physics Laboratory. His current collaborations include the US Army Research Laboratory, Defense Research and Development Canada, the National Research Council of Canada, the French-German Research Institute of Saint-Louis, and partners from the North American defense and aerospace industry.

Jamie Hogan sees himself as a conduit – for fundamental research to reach industry, for the development of large-scale collaborations, and for mentoring students to success in university and beyond. Hogan's research concerns mechanics and materials, and the design and development of materials suitable for defense applications, such as body armour and armoured vehicles. The defense industry requires new and advanced lightweight materials to reduce energy consumption and increase mobility. These materials must exhibit superior performance and possess enhanced functionalities for operation in the planet's most extreme environments, such as the Arctic.

"Traditionally in the field of military materials, to make something stronger, we just made it thicker," he says. "But then body armour becomes too heavy to carry and vehicles become too costly to fuel. So now we look to make lightweight tactical armour and vehicles."

To develop these new materials, knowledge and techniques are needed from a variety of disciplines, including Material Science, Mechanics, Design, and Manufacturing. Addressing these R&D challenges for materials is at the forefront of Dr. Hogan's Research and Development program at the Center for Design of Advanced Materials at the University of Alberta. In his lab, Hogan and his team are studying the performance of these lightweight materials in order to inform the design of military materials and equipment for maximum performance.

"We want to make lighter systems that perform better. So we select new materials or alter the microstructure of existing materials to refine and improve their performance," he explains.

While the demand for new defense materials often comes from the highest levels of government, the weight of tradition can sometimes make these demands challenging to meet. New materials for defense application are often challenging to integrate into new systems because of difficulties with machining and integration. Researchers might have a new, highly effective material for military application, but if no one can manufacture it, it is useless.

Hogan's research program brings together international collaborators, passionate graduate students, and world-class facilities to provide meaningful material solutions to government and industry sponsors.

"When you introduce a new material to the manufacturing process it introduces unknowns such as machinability, system integration, and community acceptance. For those reasons, it's a challenge to integrate into industry. I judge the success of my work on whether or not it's being applied in the field. I get a lot of gratification when industry takes my ideas and alters a manufacturing process, or when my ideas inform a policy decision."

Although some of his results are not open for public dissemination, Hogan judges his success by his extensive network of collaborators and his student's success.

"Our collaborations with the American Army and with Defense Research and Development Canada speak to the quality of our work," says Hogan. "If they didn't have confidence in our work, they wouldn't continue to work with us."

In Dr. Hogan's lab, state-of-the-art ultra-high-speeds are coupled with high strain-rate experiments at low and high temperatures in order to study the dynamic response of materials. These facilities have been developed through funding support from the Canada Foundation for Innovation, Natural Science and Engineering Research Council of Canada, and the US Department of Defense. The program pursues a balanced fundamental and applied approach to improving the performance of materials by controlling how they fail. The program's approach follows three core routes:

See it: Experiments with in-situ visualization and diagnostics capabilities are used to identify fundamental failure mechanisms in materials.

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SCHEMATIC OF RESEARCH ACTIVITIES: DESIGNING MICROSTRUCTURE FOR IMPROVED PERFORMANCE.

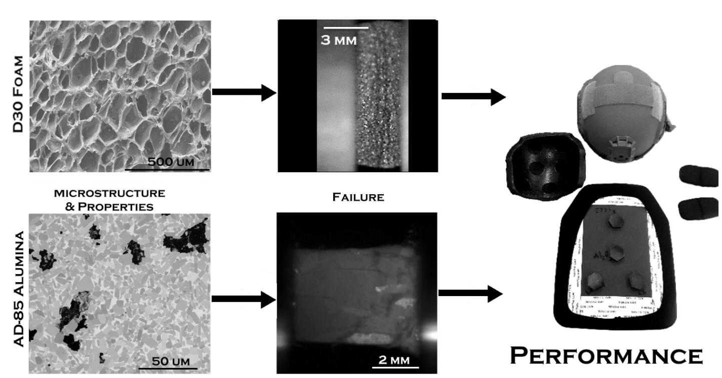


PHOTO BY: CALVIN LO / RESEARCH IMAGE PRODUCED BY BRENDAN KOCH

Understand it: Multi-scale and multi-physics models are developed for these failure mechanisms.

Control it: Insights from experiments and models are used to guide in the design and manufacturing of materials with controlled failure behavior. This is accomplished by tailoring material microstructures, properties, and architectures.

Hogan attributes much of his program's success to the efforts of the undergraduates, graduates, and postdoctoral fellows in his research program.

"I meet with them weekly to make sure they're tackling important problems" he says.

He sends his students to conferences and industry meetings, ensuring that they're prepared for the experience and trained for careers beyond their degrees.

"The attention paid to me by my mentors made a big difference to my education. I want to do the same," he says.

The continued enhancements of collaborations, student experiences, and facilities will be key for the program's long-term successes and sustainability. For James Hogan, a focus on the small things lets him make big differences. – *Robyn Braun and James Hogan*

University of Alberta Dr. **Ahmed Qureshi**

Design for additive manufacturing

DR. AHMED QURESHI IN THE ADDITIVE DESIGN AND MANUFACTURING LABORATORY (ADAM LAB) AT THE UNIVERSITY OF ALBERTA.

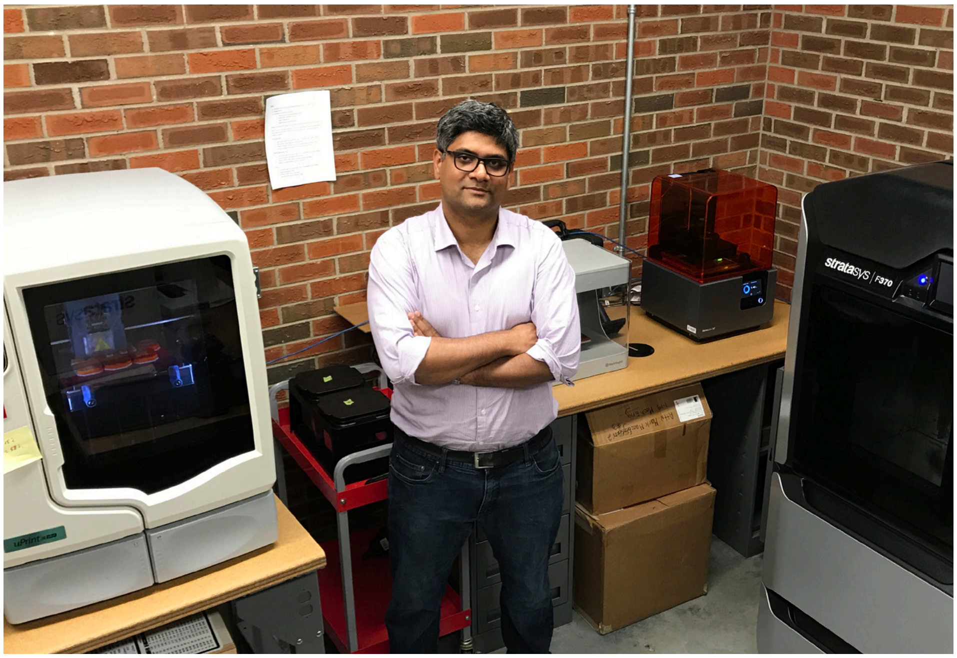


PHOTO CREDIT: RICHARD CAIRNEY

Additive Manufacturing (AM) is a manufacturing technology that realizes a product from a CAD model layer by layer through energy and material deposition to make a prototype or a functional part. Additive Manufacturing is gradually replacing conventional manufacturing processes for prototyping as well as end-user products in almost all sorts of applications ranging from manufacturing of MEMS devices to an airplane wing. In spite of this wide range of applications, in almost all types of Additive Manufacturing processes, there are still a number of unaddressed improvement areas. One of the major areas needing attention is of achieving dimensional accuracy and repeatability of mechanical properties to make the part functionally robust and interchangeable if required. These depend on a very strong coupling between the geometric design of the product, material, and the AM process being considered. Dr. Qureshi's research is focused at this nexus to improve the current state of AM processes and design for additive manufacturing and is conducted at the Additive Design and Manufacturing laboratory (ADaM Lab) at the University of Alberta.

Current research projects at the ADaM lab are divided into: AM systems development; AM materials development; design for AM processes; and, engineering design and methodology. In the area of AM systems development, in collaboration with Innotech Alberta, with regards to Alberta's industrial needs, ADaM Lab developed Alberta's first Plasma Transfer Arc AM system. The system enables production of high hardness non-machinable high wear resistance materials. The laboratory, in collaboration with advanced composites laboratory at the University of Alberta has also developed novel ferromagnetic resins for 3D printing via vat photo polymerization processes. The laboratory is also actively engaged in design for additive manufacturing research with a focus on tolerance modeling and optimization, assembly consolidation, and dimensional assurance of printed parts.

Dr. **AHMED QURESHI**, PhD

Dr. Ahmed Qureshi is an Assistant Professor in the University of Alberta. After obtaining his undergraduate degree in Mechanical Engineering, he started his professional engineering career in chemical process industry in the area of turbo machinery reliability, maintenance and operations management. He obtained his Master degree in 'Design, Industrialization and Innovation' from the French Grande Ecole Arts et Métiers ParisTech, Metz, France, with specialization in detail design and tolerance optimization in 2007 and a PhD in robust design of mechanical systems in 2011. Following this, Dr. Qureshi joined the Engineering Design research group at the University of Luxembourg where he researched transdisciplinary engineering design processes in engineering design and manufacturing sector. He also worked as a lecturer in integrated design and manufacturing at the Newcastle University before starting his current position at the University of Alberta. Dr. Qureshi's current research interests are in the area of Additive Design and Manufacturing with a focus on design for additive manufacturing and design of manufacturing systems. He also has ongoing research projects in transdisciplinary engineering design methodologies and tolerance and variation management in mechanical systems.

Dr. **JAMES DOUGLAS DALE**, PhD, P.Eng., FASTM, FCAE, FEIC

Dr. Dale is Professor Emeritus of the Department of Mechanical Engineering, University of Alberta. He received his PhD from the University of Washington in 1969, specializing in heat. Dr. Dale is/was a member of ASHRAE, ASME, ASTM, CSME, Combustion Institute, NFPA and SAE, serving on numerous committees within these organizations. His current research activities involves developing test methods for evaluating the performance of thermal protective clothing worn by people who work in the oil and gas industries, fight wildland fires, fight fires in structures and serve in the military. The results are being used in standards and test methods in ASTM, CGSB, ISO and NFPA.

When did you start working as a Mechanical Engineer in Canada? Tell us about the status of the field during that period of time.

I started working in HVAC design for a consulting company in May, 1961. The calculation of heating and air conditioning requirements were well established, thanks to technical organizations such as ASHRAE, which published handbooks specifically for designers. Certainly, there were "rules of thumb" that senior engineers had developed over the years that were used to check on items like the energy input requirements for heating and air conditioning of buildings in the local area. Calculations were done by hand using slide rules, logarithm tables and mechanical adding/multiplying machines.

How do you think the field of Mechanical Engineering has evolved in Canada over the course of your Career?

All disciplines in engineering have evolved from simple analysis and rules of thumb to detailed and sophisticated analysis via computer codes. The early versions were simplistic, being modelled on how hand calculations were done. Over time these computer codes have upgraded to include more fundamental science as the knowledge was acquired and proved, especially at the nano scale.

What do you think is the greatest Canadian contribution to Mechanical Engineering? And how can we make such an impact again in Canada?

Energy systems: CANDU reactor, oil and gas development, heavy oil and bitumen extraction, and pipeline networks. Impact again: bioengineering, artificial limbs and tissue engineering.

What is your most significant contribution to the field of Mechanical Engineering and why?

I will mention three.

Laser Ignition for Internal Combustion Engines – world's first experiment (1977). Demonstrated potential to raise the brake thermal efficiency of large natural gas fuelled engines from 40 to 50 per cent.

Heat Loss Studies for Residential Housing – upgrades to the National Energy Code for houses and buildings in 1995. Home owners in the Prairie Region of Canada save approximately $1 million per year. Results also integrated into U.S. DOE Foundation research panel study. Dollar savings equal approximately $1 billion per year.

Development of test methods for evaluating the thermal protective performance of clothing worn by personnel who work in the oil and gas industries, fight wild land fires and structural fires and military applications. The information is used directly in Standards and Test Methods in Canada (CGSB), the U.S. (ASTM and NFPA) and throughout the world through ISO.

Where do you think Mechanical Engineering is heading in Canada in the next 10 years?

Automation (robotics) including artificial intelligence (AI), nanotechnologies, additive manufacturing and new materials.

You have been working in the area of thermo-fluids and combustion for many years and have experienced first-hand the oil sands boom in Alberta, as well as the growing concerns regarding climate change. Will engineers be able to balance Canada's growing oil and gas energy industry with the environmental damage they are causing? What advice would you give to the future generations of engineers in the province of Alberta, and Canada?

Are the engineers causing the damage, or people who demand more energy to improve their quality of life?

There is no doubt that resource development has its complications in producing environmental damage. The record shows that in the oil sands area that the efficiency of extracting the oil, separating it from the parent material and converting it into desired end products (heating oils, diesel fuels and gasolines) has greatly improved, and approaches that of conventional drilling. Ideally the increasing use of renewable energy will reduce the demand for fossil fuels, helping the environment attain some equilibrium.

PHOTOS COURTESY OF DR. DALE

Using renewable energy is not without its own problems. For example bird kills by wind turbines.

The problem, of course, is simply overpopulation by humans and their desire to attain some living standard with which they are comfortable.

How do you think we are going to provide energy to the expected 10 billion people in the world by the end of this century?

Solar, wind, wave and fusion.

What is your opinion about research funding in Mechanical Engineering in Canada? How can we improve the support of fundamental and applied research in this field?

I believe that Canada, as a nation, provides less support for research as a percentage of the GDP than the other G7 countries. In some respects, this is understandable because of our close relationship with the U.S. We have access to their research through international companies that operate in Canada. That said, Canada could be doing more, especially in dealing with the development of the North and environmental problems associated with resource development.

It is unlikely that Canada will become, relatively speaking, a manufacturing powerhouse. The development of low-cost shipping of mass produced goods by sea overrides large scale production of consumer goods in North America. Canada needs to focus on advanced manufacturing methods in specialized areas.

You have been an instructor for over 30 years, how would you describe the differences between the undergraduate students in 1970s and today? Also, have you seen many changes in the professors' attitudes over the years? Any recommendations for the next generation of academics in engineering?

I have not lectured to students for about 15 years. Thus, I can not really comment on differences....

Professors, young and old, adapt to the times. In the 1970's the emphasis was on developing good lecturing skills and ideally having some applied or industrial experience to illustrate and enhance the lecture material. Now, new faculty rarely have any lecturing assignments in their first employment term so they can spend time focusing on setting-up their research program and seek outside funding. Usually they are given some funding from the university to jump start the process. Thus, they are given a clear message that research is most important and lecturing is secondary. The profession (those that practice engineering, design and manufacturing items for the benefit of mankind), have concerns about this change in emphasis.

Recommendation: learn to be adaptable as change is one of the certainties in life.

. . . . Canada 150 and MechE continued from page 7

Since the year 2000, in the public's mind, the dominant engineering discipline has perhaps been the electronic one, with its IT systems, computers and 'iproducts.' But mechanical engineers have nevertheless been busy with, for example, robots and advanced energy and manufacturing systems, computerized fluid dynamics, mechatronics and nanotechnologies. And the word 'innovation' has become part of every day's vocabulary.

The names of Canadian engineers of any discipline are seldom recognized by the general public. Very few ever seek political office and, in that capacity, are considered politicians rather than engineers. Those recognized as distinguished within the profession during the 19th century are, once again, predominantly civils - for example, Sandford Fleming, Thomas Keefer and Casimir Gzowski. A 20th century list would be more broadly based and might include mechanicals such as Casey Baldwin, Rupert Turnbull, George Klein, Armand Bombardier, Ian Gray, Earl Dudgeon, Tom Brzustowski, Martha Salcudean and Chris Hadfield.

CSME, as a learned Society, is currently only three years short of 50 years old. The original Canadian Society of Civil (as opposed to military) Engineers, founded in 1887, was dominated by civils, but included a few mechanicals. Indeed, of its first 15 presidents, only two were mechanicals. However, by the end of World War I, the Society had become the Engineering Institute of Canada and its membership included a relatively large number of mechanicals. By the mid-1960s, the Institute was no longer able to provide all of the appropriate services, nor to compete as a learned society with the larger American Societies and the increasing number of specialist ones that were being formed. So it became a federation of semi-autonomous, discipline-oriented societies, of which CSME was the first to be founded, in 1970. By the mid-1980s, the societies within the federation had gained full autonomy, and were permitted to incorporate, with a diminished role for the Institute. When formed, CSME's membership included many industrial and government engineers from the practice side of the profession. Nowadays, its membership is drawn mostly from academia and from research or development activities. A Canadian Academy of Engineering was founded in 1987, and many mechanicals are now members.

In 1867 there was perhaps one professional engineer in Canada for every 15,000 citizens, and almost all were civil engineers. In 2017, there is one for every 175 citizens, and roughly one in three is a mechanical.

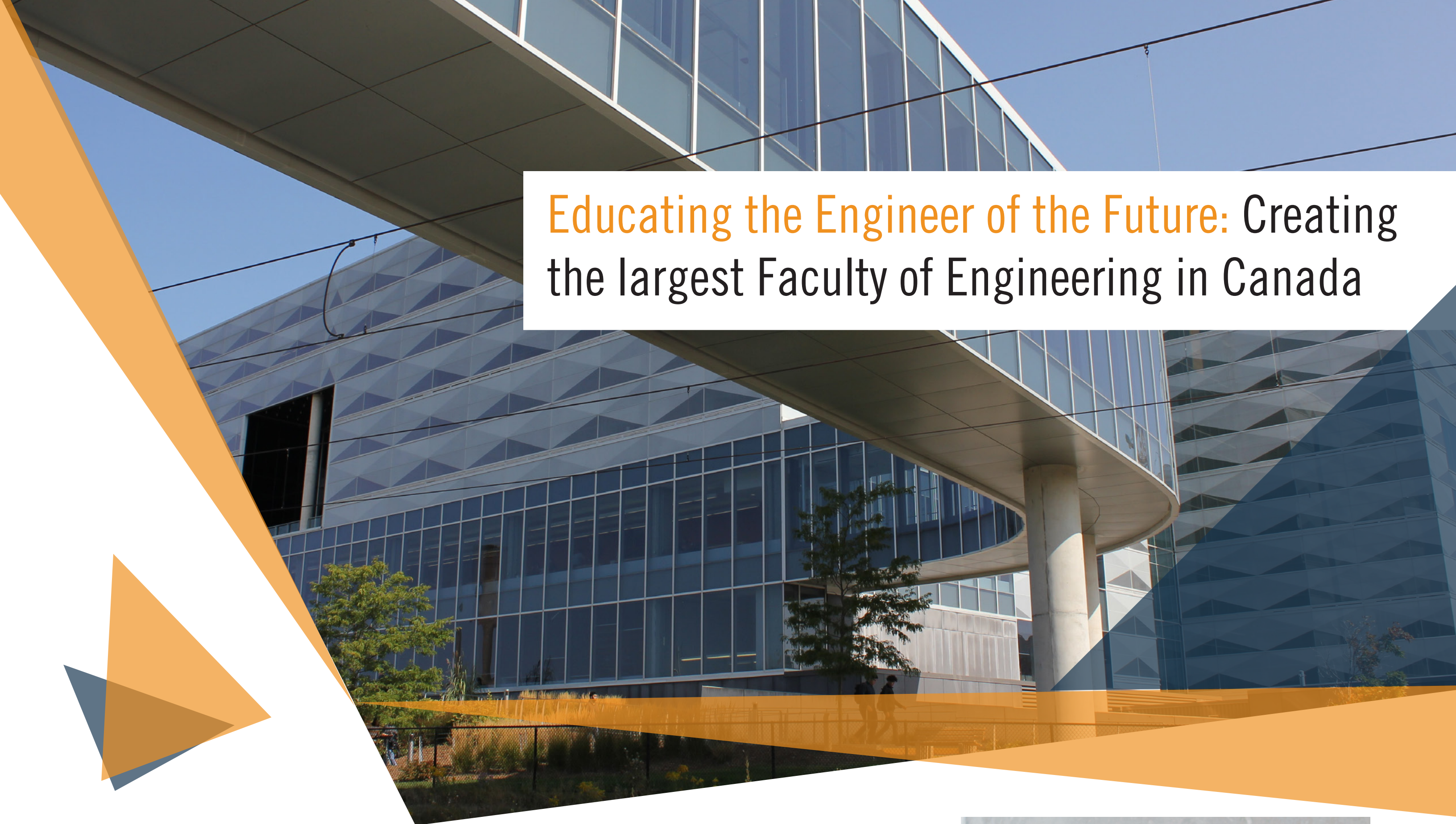
. . . . Future Energy Systems continued from page 9

Some Future Energy Systems projects have research teams representing three different University of Alberta faculties – for example: engineering, business, and agricultural, life, and environmental sciences. The HQP involved in these projects have the opportunity not just to grow within their fields, but also to build an understanding of how their work fits within a broader context, and to build connections that can help them launch careers upon graduation in the corporate, governmental and academic sectors.

Other projects are more specialized and discipline-specific, but because of the continuity of funding, are able to undertake unique research. For instance, many of our engineering projects involve the development of new technologies such as ultra-low temperature differential engines, flywheels, smart grid management switches, and electrolyzers. Because of the stability of funding, the HQP working on these projects will have the opportunity to gain experience with numerous aspects of the technological development process, including fundamental research, design and production of prototypes, refinement, and in some cases, work with corporate partners to move towards commercialization.

Future Energy Systems will make significant contributions to Canadian and global energy technology research in the years ahead, and will help launch the academic and private-sector careers of countless young engineers, scientists, and other academic experts. Additional information about the program, its current and upcoming research projects, and opportunities for engagement can be found at www.futureenergysystems.ca.

Students interested in joining the University of Alberta to become part of the program can also consult the website to determine whether their expertise might be compatible with our research portfolio. Individual Principal Investigators have complete hiring discretion for their projects, but expressions of interest made through the Future Energy Systems website can be forwarded for their consideration.



Educating the Engineer of the Future: Creating the largest Faculty of Engineering in Canada

AS OUR FOUNDING FATHERS PIONEERED CO-OPERATIVE EDUCATION IN CANADA 60 years ago, Waterloo Engineering continues to transform engineering education. Innovation has been a hallmark of Waterloo Engineering. We've transformed how engineers learn, challenging our students to tackle the truly difficult problems so they are uniquely prepared to be the engineers of the future.

We have worked to create an environment that allows students to reach their fullest potential and live their aspirations. With our world-leading research institutes and centres – many deeply involved in emerging and disruptive technologies – Waterloo Engineers are having a profound impact on the future of technology around the world.

As Canada's largest engineering school, we have the responsibility to help advance engineering education for the 21st century. It is our purpose to prepare the next generations of Canadian engineers with the deep knowledge, critical thinking skills, ethical grounding, ingenuity and confidence to adapt and succeed in even the most challenging conditions of tomorrow.

Waterloo Faculty of Engineering lives and breathes a culture of excellence and we continue to raise the bar by providing even earlier opportunities to experience what it is to be an engineer. We work hard to support research at the highest levels and also nurture those with entrepreneurial aspirations.

Canada is striving to foster widespread innovation. Our Faculty has a long record of putting ideas to use – from conceptualization to execution. We have worked with over 1,000 industry, government and non-for-profit partners in research and development. Our alumni, students and faculty have started 600 + new ventures that are employing thousands, and our over 43,000 alumni have contributed to nation building.

With the near completion of our student-focused Engineering 7 (E7) building, due to open Fall 2018, we will be able to accommodate our expanding engineering programs – since 2005, we have seen a 40 per cent increase in engineering undergraduate enrolment and a 58 per cent increase in our graduate numbers. By 2020, we will add another 1,300 students to our current student body of over 9,000.

We are committed to enhancing our students' learning experience – whether in international co-op/exchange, research in state-of-the-art labs, or testing an entrepreneurial concept. We have no doubt that the student-centric design of E7 will be the genesis of new ideas and engineering solutions that have yet to be imagined. – *As narrated by Professor Pearl Sullivan*

DR. PEARL SULLIVAN, PhD,
DEAN, FACULTY OF ENGINEERING
UNIVERSITY OF WATERLOO

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Associate Editor / Éditeur associé, *Bulletin*	Marc Secanell, MCSME	secanell@ualberta.ca
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Managing Editor, 2017 ***Transactions*** / Rédacteur administrateur, 2017 *Transactions*	Ilian Bonev, FCSME	ilian.bonev@etsmtl.ca
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Administrative Officer / Agent administratif	Mohammud Emamally	admin.officer@csme-scgm.ca

CSME Address / Adresse de la SCGM

P.O. Box 40140, Ottawa, ON, K1V 0W8

Phone / Téléphone 613.400.1786 Email: admin.officer@csme-scgm.ca www.csme-scgm.ca

The CSME would like to acknowledge the support from the following ME Departments
La SCGM tient à remercier les départements de génie mécanique suivants pour leur aide

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