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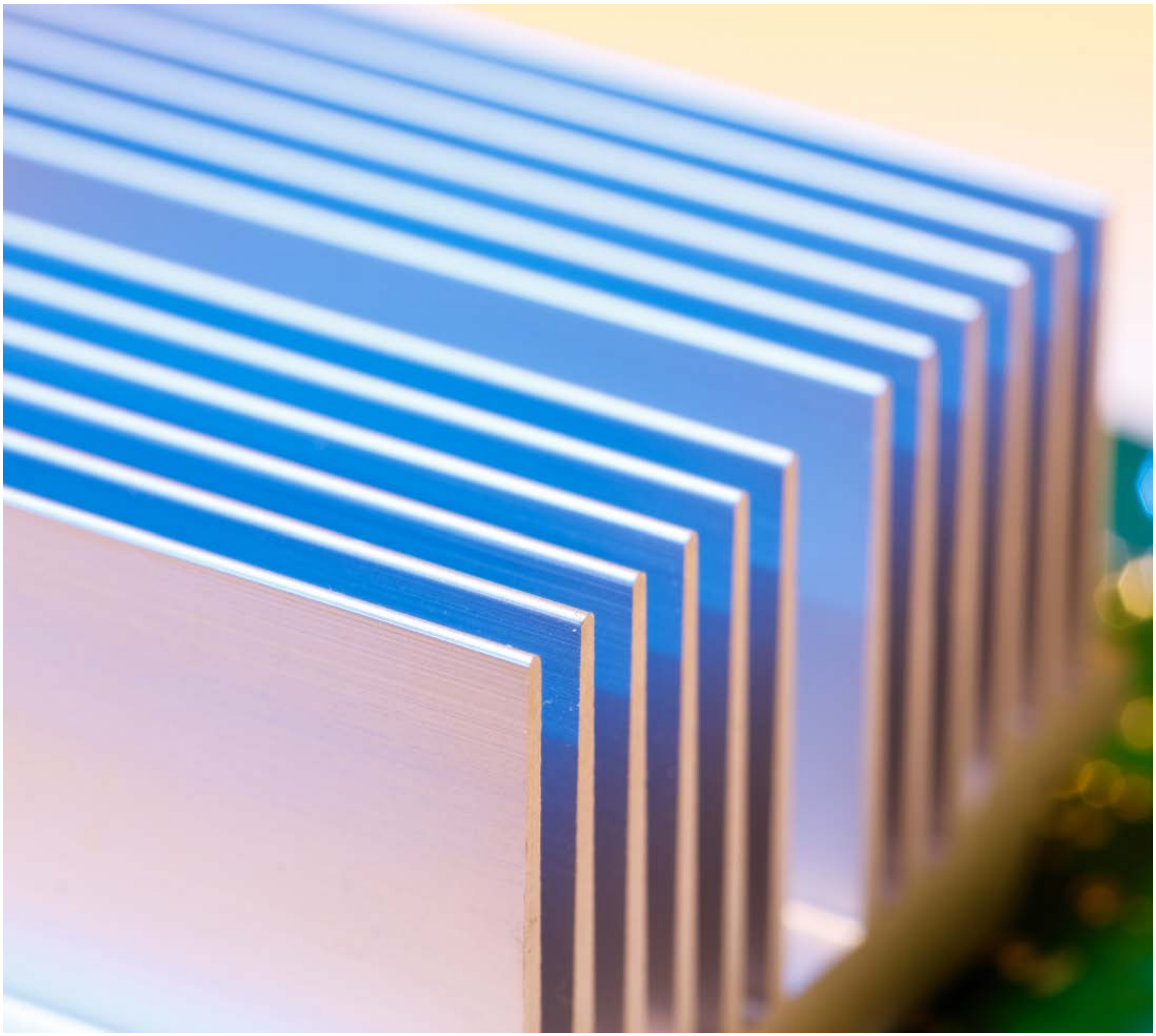
LA SOCIÉTÉ CANADIENNE DE GÉNIE MÉCANIQUE
SPRING/PRINTEMPS 2020

BULLETIN



SPECIAL ISSUE ON

Heat Transfer

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Editor's Letter

OUR SOCIETY AND ITS MEMBERS HAVE HAD TO adapt to the challenge of the COVID 19 pandemic. Undoubtedly, the pandemic has affected many of our member's lives, as well as our society. We wish you all health and fast recovery from the impacts. Also, we regret the cancellation of the 2020 CSME Congress.

The current CSME *Bulletin* issue has a thematic focus on *Heat Transfer*. Given Canada's northern geographical location, engineers working on heat transfer play a critical role in our daily lives, from the development of insulation to keep our houses warm and prevent pipe damage due to freezing during the winter, to the implementation of engineering controls to facilitate the introduction of technologies that might not be ideally suited to our cold winters, such as electric vehicles.

In this issue, we have provided Featured Articles from four leading Canadian groups directed by professors **Park**, **Kishawy**, **McDonald** and **Handan**. They have highlighted some of their most recent research activities on thermo-conductive polymer composites, electric vehicles thermal management, thermal sprayed coatings of pipelines, and thermal energy storage for space heating. In the *New Faculty Spotlight* section, we are highlighting the research programs of Dr. **Tetreault-Frind** on heat transfer in advanced nuclear and solar-thermal energy technologies, Dr. **Mahshid** on microfluidic devices, Dr. **Hemmati** on turbulence and computational fluid dynamics, Dr. **Lalole** on the development of comprehensive biomechanical models of the hand and upper limb, and Dr. **Shadmehri** on composite materials,

We are delighted to have an article from the chair of the Mechanical Engineering Department at the University of Victoria, Prof**. Nick Dechev**. His article highlights the excellent faculty that can be found at Canadian universities, and the role they play in the development of technological solutions to critical societal needs such as biomedical engineering and sustainable energy.

The ME News section, written by Dr. **Willing**, nicely highlights the research of Dr. **Groulx** at Dalhousie University on phase change material for smartphone cooling and Dr. **Kempers** at York University on thermally conductive 3D-printed fiber polymer composites for heat exchangers. We also invite you to read updates from the Editor of *Transactions of the CSME* and the chairs of the *Technical Committees* and *CSME Student and Young Professionals* committee.

We started this letter discussing the challenges our society faces due to the COVID-19 pandemic. During the initial stages of the pandemic, Mechanical Engineers (ME) in Canada acted fast to develop technological solutions to aid in the fight against the COVID-19 disease. Therefore, we have decided to dedicate the next CMSE *Bulletin* issue to highlight their work. We look forward to receiving your contributions such as featured articles, faculty spotlights, and news and views.

Please contact us if you are interested in contributing to the next issue. As always, we look forward to receiving your comments about the CSME *Bulletin*.

We hope you enjoy reading this issue,

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PHOTO (REZAI): COURTESY OF THE LASSONDE SCHOOL OF ENGINEERING, YORK UNIVERSITY / PHOTO (GALLART): TABITHA GILLMAN

President's Message

Message du président

Dear CSME Colleagues,

THIS IS THE SECOND LETTER THAT I PREPARED FOR THE CURRENT EDITION OF THE CSME BULLETIN. Being well organized, I prepared my first letter in early March, which is much in advance of the publication deadline. In that letter, I discussed the forthcoming 2020 CSME Congress and other issues which seemed important at that time. And then the pandemic came, and the world changed. My university is locked down and I cannot even enter my office. The only thing which seems to be certain is that we will be living in a different world once the pandemic is over, it is unclear how this world will look like. The virus will likely stay with us and this will affect how we will behave.

We face a time of extraordinary challenges due to the ongoing COVID pandemic concerns. We know, however, that our ME community will be resilient and resourceful in the face of crisis as the world confronts the pandemic. This spirit is also seen in ME departments and labs worldwide, where academic colleagues have suspended research with almost no prior warning, and students and staff have dispersed. Now and in the coming weeks, we will all be called upon to do what we can to keep our communities healthy, keep our research and education missions alive, and prepare for an uncertain future. CSME has made a few operational adjustments in order to cope with these challenges.

The CSME International Congress that was to be held in Charlottetown, PE on June 21-24, 2020 has been postponed until the summer of 2021. The next two scheduled CSME Congresses have been similarly postponed, i.e. the 2022 Congress will be held in Edmonton, AB, and 2023 in Sherbrooke, QC. The 2020 Annual General Meeting (AGM) of the CSME, which was to take place during the 2020 Congress, has been postponed till late fall 2020. The venue, time and date will be announced before the end of summer. Hopefully, the COVID pandemic and situation in Canada will have been resolved by then. As a registered non-profit organization, the CSME is obliged to carry out annual financial audits. Results of the 2019 financial audit will be presented at the fall AGM for discussion and approval. The terms of directors on the Board normally expire at the AGM when re-appointments and new appointments are put to a vote by general members via a Nominating Committee report. Current directors will thus remain in their roles/functions until the 2020 AGM has successfully been held. The current CSME Bylaws require that its Annual General Meetings (AGM) be held in person. A proposal will be placed at the next AGM to amend the bylaws to allow for electronic meetings as is now typically allowable.

We are in the process of restructuring the CSME History committee and I am sure that one of its areas of interest will be documenting how we dealt with the pandemic. Please collect information documenting the efforts of our members in addressing challenges resulting from the pandemic. Finally, please accept the Society's and my own best wishes to you and your families. We hope that you are able to stay healthy and strong.

Best,

MACIEJ FLORYAN, PhD, P.Eng. FAPS, FASME, FCSME, FCASI, FEIC, FJSPS, FCAE, AFAIAA
CSME *President*
Professor, Western University
Department of Mechanical and Materials Engineering

Chers collègues,

Ceci est ma deuxième lettre préparée pour l'édition actuelle du *Bulletin* de la SCGM. Bien organisé, j'avais préparé la première ébauche en début mars. Dans cette ébauche, je discutais du prochain congrès de la SCGM 2020 et d'autres questions qui semblaient importantes à l'époque. Et puis la pandémie est venue, et le monde a changé. Mon université est fermée et je ne peux même pas entrer dans mon bureau. La seule chose qui semble certaine, c'est que nous vivrons dans un monde différent une fois la pandémie terminée — on ne sait pas à quoi ressemblera ce monde. Le virus restera probablement avec nous et cela affectera nos comportements.

Nous sommes confrontés à une période de défis extraordinaires en raison des préoccupations actuelles liées à la pandémie de la COVID. Nous savons cependant que notre communauté IM sera résiliente et ingénieuse face à la crise alors que le monde affronte cette pandémie. Cette attitude se retrouve également dans les départements et les laboratoires IM du monde entier, où des collègues universitaires ont suspendu leurs recherches sans préavis et où les étudiants et le personnel se sont dispersés. Maintenant et au cours des prochaines semaines, nous serons tous appelés à faire ce que nous pouvons pour maintenir nos collectivités en santé, maintenir nos missions de recherche et d'éducation en vie et nous préparer à un avenir incertain. La SCGM a procédé à quelques ajustements opérationnels afin de faire face à ces défis.

Le congrès international de la SCGM qui devait se tenir à Charlottetown, PE en juin 2020 a été reporté à l'été 2021 (27-30 juin). Les deux prochains congrès prévus ont également été reportés, c'est-à-dire que le congrès 2022 se tiendra à Edmonton, AB et celui de 2023 à Sherbrooke, QC. Quant à l'assemblée générale annuelle (AGA) 2020, elle se tiendra à la fin de l'automne 2020. Le lieu, l'heure et la date seront annoncés avant la fin de l'été en espérant que la pandémie et la situation au Canada auront été résolues d'ici là. En tant qu'organisation à but non lucratif, la SCGM est tenue de réaliser des vérifications financières annuelles. Les résultats de la vérification 2019 seront présentés à l'AGA pour discussion et approbation. Les mandats des administrateurs expirent normalement lors de l'AGA lorsque les reconductions et les nouvelles nominations sont soumises au vote des membres généraux. Les administrateurs actuels resteront donc dans leurs rôles / fonctions jusqu'à la tenue de l'AGA 2020. Les statuts actuels de la SCGM exigent que ses assemblées générales soient tenues en personne. Une proposition sera déposée lors de la prochaine AGA pour modifier les statuts afin de permettre les réunions entièrement électroniques.

Nous sommes en train de restructurer notre comité d'histoire et je suis sûr que l'un des domaines d'intérêt sera de documenter comment nous avons géré la pandémie. Veuillez collecter des informations documentant les efforts de nos membres pour relever ces défis particuliers. Enfin, veuillez accepter les vœux de la Société et mes meilleurs vœux à vous et à vos familles. Nous espérons que vous pourrez rester forts et en bonne santé.

Cordialement,

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3D PRINTED FACESHIELDS FOR ISLAND HEATH

Insight to the Department of Mechanical Engineering at the University of Victoria

DR. NICK DECHEV, PhD

Dr. Dechev is an Associate Professor and is currently Acting Chair of the University of Victoria's Department of Mechanical Engineering, since July 2018. He was previously Director of the Biomedical Engineering program for four years. He has teaching interests in design engineering, mechanics and mechatronics.

DR. STEPHANIE WILLERTH, PhD

Dr. Willerth is a Professor in Biomedical Engineering at the University of Victoria and holds a Canada Research Chair in Biomedical Engineering where she has dual appointments in the Department of Mechanical Engineering and the Division of Medical Sciences. She also holds an appointment with the School of Biomedical Engineering at the University of British Columbia. She serves as the Acting Director of the Centre for Biomedical Research and the Biomedical Engineering undergraduate program at UVic.

PHOTOS COURTESY OF THE UNIVERSITY OF VICTORIA

THE MECHANICAL ENGINEERING DEPARTMENT at the University of Victoria serves as the home of incredible researchers and teachers who actively promote a vibrant culture of productivity and excellence. We currently educate over 500 undergraduate students majoring in Mechanical Engineering as well as over 100 graduate students. Our Department also supports our edge program in Biomedical Engineering, which is now home to over 130 undergraduates. Our major areas of research focus include aerospace research, biomedical engineering, and energy systems with a focus on sustainability. The department consistently brings in significant external research support while maintaining high levels of productivity. We are especially proud of our highly cited researchers like Dr. **Yang Shi** and Dr. **Ned Djilali** and our teaching award winning faculty like Dr. **Bradley Buckham** who won the Medal for Distinction in Engineering Education by Engineers Canada in 2019 as well as the EGBC Teaching Award in 2018 and Dr. **Stephanie Willerth** who won the 2018 University wide REACH award for for Excellence in Undergraduate Research-inspired Teaching. In terms of research excellence, Dr. **Afzal Suleman**, a Tier I Canadian Research Chair in Computational and Experimental Mechanics, runs the Centre for Aerospace Research – an internationally recognized facility developing experimental aircraft that serves as a nexus for collaboration with industrial partners like Viking Air. He also serves as the faculty advisor for our student clubs focusing on rocketry and satellite design. We have further supplemented our strength in advanced manufacturing with Dr. **Keivan Ahmadi** whose work focuses on machining processes. He has published several recent journal articles in this area.

Our department also has significant strength in the area of biomedical engineering. Dr. **Stephanie Willerth** currently serves as the acting director of the undergraduate Biomedical Engineering program and she also holds a Canada Research Chair in Biomedical Engineering. Her research lab focuses on 3D bioprinting neural tissues from stem cells. She, along with Dr. **Mohsen Akbari** – a rising star in the field of tissue engineering, have brought in significant health related funding to the department, including recent awards from the Michael Smith Foundation for Health Research. Dr. Akbari has developed novel technologies for wound healing applications and has founded the start-up company 4M Biotech Limited. Our recent recruitment from Imperial college in the U.K. – Dr. **Josh Giles** – has brought the department expertise in the area of biomechanics and was recently awarded funding from the Canadian Foundation for Innovation. We currently have a proposed Master of Engineering program in Biomedical Systems in the works, to be launched for Fall 2021, to expand our graduate offering. Our department also serves as the base of operations for the Victoria Hand Project – a non-profit lead by Dr. Dechev, that provides upper-limb prosthetics to amputees in developing and resource-poor countries. This compliments his research program in assistive technologies for disabled persons, provision of 3D printed prosthesis, and development of orthotic braces for children suffering from scoliosis.

Another major pillar of strength in our department is our world class work focusing on the area of energy systems. Dr. **Andrew Rowe**, a full professor of Mechanical Engineering, directs the Institute for Integrated Energy Systems and he actively participates in the 2060 project – evaluating energy systems use and their impacts by focusing on reducing greenhouse gas emissions. Other featured projects with an emphasis on energy systems include the West Coast Wave Initiative, analyzing the use of energy derived from the oceans, and the Sustainable Energy Systems Integration & Transitions group, who examine sustainable energy transitions.

Overall, we are proud of our Department of Mechanical Engineering here at the University of Victoria and we look forward to growing as part of the B.C. wide Engineering Expansion project, including a new building here at the University.

Welcome New CSME members

1 October 2019 to 30 April 2020

Prof. Hamid Akbarzadeh, *McGill University – Bioresource Engineering Department*
Mr. Harith Al Najjar, *Arrowquip*
Mr. Samer Al-Ayash
Dr. Rustom Bhiladvala, *University of Victoria*
Mr. Gregory Brown, *Patriot Forge Co*
Mr. Apurba Kumar Chakraborty, *Chittagong Port Authority (Bangladesh)*
Dr. Alireza Dehghanisanij, *Memorial University of Newfoundland*
Prof. Ibrahim Deiab, *University of Guelph*
Dr. Giuseppe Di Labbio, *Polytechnique Montréal*
Mr. Guy Didcott, *Cumulative Trading Solutions (South Africa)*
Prof. Darrel Doman, *Dalhousie University*
Mr. Kelechi Ezeji, *Bombardier Aerospace*
Dr. Wei Huang, *National Research Council*
Prof. Thomas Jenkyn, *Western University*
Dr. Cuiying Jian, *York University*
Prof. Xiaoliang Jin, *University of British Columbia*
Prof. Emily Lalone, *Western University*
Mr. Prasanthraja Anton Mackmilan, *University of Lincoln (UK)*
Dr. Giulio Malinverno, *Advanced Technology Valve Spa (Italy)*
Prof. John Medley, *University of Waterloo*
Mr. John Samuel Parcon, *Lumiant Corporation*
Mr. Senthil Kumar Murugappan, *Lufa Farms Inc.*
Dr. Kee Seung Oh, *Queen's University*
Mr. Paul Onyigbuo, *Gamstec Integrated Services Ltd (Nigeria)*
Dr. Sadia Siddiqa, *COMSATS University Islamabad, Attock Campus (Pakistan)*
Dr. Shidvash Vakilipour, *University of Manitoba*
Mr. Tyson Wahrenburg, *Husky Energy*
Prof. Norman Wereley, *University of Maryland*
Prof. Fengfeng Xi, *Ryerson University*

Transactions of the Canadian Society for Mechanical Engineering (TCSME)

I am happy to report on the accomplishments of the *Transactions* of the Canadian Society for Mechanical Engineering (TCSME) for the year 2019. In 2019, we have published four issues with a total number of 59 articles. Also in 2019, based on the Web of Science articles published either in 2017 or 2018 were cited 61 times which is a good indication that the impact factor for 2019 will be higher than 0.50. Until recently in 2020, the most cited article is:

"Mechanical, wear and thermal behaviour of hemp fibre/egg shell particle reinforced epoxy resin bio composite" Inbakumar, J. Parivendhan; Ramesh, S. *Transactions of the Canadian Society for Mechanical Engineering*, Sept. 2018, Vol. 42, Issue 3: p. 280-285

MARIUS PARASCHIVOIU, PhD, FCSME
Editor-in-Chief, TCSME
Professor, Mechanical, Industrial and Aerospace Engineering
Concordia University

Computational Mechanics Technical Committee

The Computational Mechanics Technical Committee finalized its website (www.csme-scgm.ca/content/computational-mechanics).

It also planned to host two sessions during the 2020 International CSME Congress *(postponed until the summer of 2021)*:

(i) "Computational Heat and Fluid Flows: Algorithm Development and Non-standard Applications" co-chaired by **A. Komrakova** from the University of Alberta and **Ida Karimfazli** from Concordia University

(ii) "Artificial Intelligence in Computational Mechanics" chaired by **J.M. Floryan** from Western University

– J. M. Floryan

Thermoconductive Polymer Composites and Foams with Tailored Directional Heat Transport and Electrical Properties

Dr. MAHDI HAMIDI, PhD

Dr. Hamidi holds a joint appointment as an NSERC Postdoctoral Fellow in the Department of Mechanical Engineering at University of California-Berkeley and University of Toronto. Dr. Hamidi received his PhD from University of Toronto on Advanced Manufacturing of Functional Nanocomposites. He has also obtained another PhD in solid mechanics from Ryerson University, a BScand a MASc in Mechanical Engineering from Iran. He has been the recipient of several prestigious awards including NSERC Postdoctoral Fellowship (2019), NSERC Michael Smith Foreign Study Supplement (2018), NSERC Alexander Graham Bell Canada Graduate Scholarship (2017) and the Ontario Graduate Scholarship (2016).

Dr. TOBIN FILLETER, PhD, P.Eng.

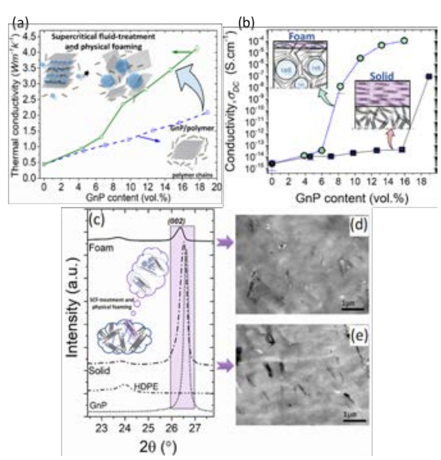
Dr. Filleter is the Erwin Edward Hart Professor of Mechanical & Industrial Engineering at the University of Toronto. He received a BSc in Engineering Physics from Queen's University in 2003, and a PhD in Physics from McGill University in 2009. Prior to joining the University of Toronto, Prof. Filleter was a Postdoctoral Fellow in the Department of Mechanical Engineering at Northwestern University from 2009-12. Prof. Filleter leads the Nanomechanics and Materials Laboratory (NanoM2) at U of T which conducts cutting-edge research in the fields of nanomechanics and nanotribology. He is the recent recipient of the 2014 I.W. Smith Award from the Canadian Society for Mechanical Engineering (CSME), 2016 Early Researcher Award from the Ontario Ministry of Research and Innovation (OMRI), and 2017 Connaught New Researcher Award.

Dr. CHUL B. PARK, PhD, P.ENG., FRSC, FCAE, FKAST, FNAEK, FAAAS, FASME, FCSME, FEIC, FSPE

Chul B. Park is Distinguished Professor of Microcellular Engineered Plastics at University of Toronto. He is also the NSERC Senior Industrial Research Chair in Multi-Functional Graphene-Based Polymer Nanocomposites and Foams. He has an international recognition in the polymer foam area. Prof. Park has published more than 1400 papers, including over 370 journal papers and four books with 68 Scopus H-index. Prof Park serves as the Editor-in-Chief of the Journal of Cellular Plastics*, and sits on the Advisory Editorial Board of several journals. He has been inducted into 4 academies of the Royal Society of Canada, the Canadian Academy of Engineering, the Korean Academy of Science and Technology and the National Academy of Engineering of Korea as a Fellow. He is also a Fellow of five other professional societies and has received over 80 awards.*

IMAGES COURTESY OF THE RESEARCHERS

FOR DECADES, CONTINUOUS MINIATURIZATION and high-power densification have been the hallmark of microelectronic device development[1]. However, overheating is often the greatest barrier to further miniaturization due to high functional and power density requirements[1]. Thus, effective heat dissipation is crucial to guarantee optimal performance and extend the service life of microelectronic devices[2]. Lightweight, multifunctional, low cost, and highly thermally conductive polymer composites show promise for use as heat dissipation components[2,3]. When compared with metallic and ceramic composites, polymer composites have an attractive array of properties, including ease of processing, superior resistance to chemicals and corrosion, and tailorable physical/mechanical properties[2,3]. The thermal conductivity of polymer composites is intensely affected by their interfacial thermal resistance and interfacial phonon scattering[4], by their dispersion and orientation, and by the type of fillers used[2,3]. With the recent advances in nanomaterials and their growing availability, the types and functions available for polymer composites have been significantly increased. Graphene nanoplatelets (GnPs) and Hexagonal Boron Nitride (hBN) with excellent thermoconductivity and attractive array of electrical and dielectric properties are highly promising materials for the fabrication of thermoconductive polymer composites with tailored electrical properties[2,3]. However, the practical underpinning needed to economically manufacture GnP- and hBN-based polymer composites is missing. It has been extremely challenging to exploit graphene and hBN's full potential. This has been due to the complexities that exist in the exfoliation, dispersion, and control of the hBN and graphene nanoplatelets (GnPs) and their orientation within the composites[2,3].



Our research demonstrates how critical challenges for efficient manufacturing of thermoconductive polymer composites can be overcome by engineering the microstructure through supercritical fluid (SCF)-treatment and physical foaming technologies. Our research work contributes to in-depth understanding of processing-structure-property relationships of the thermoconductive polymer composite containing graphene[2], and hexagonal boron nitride (hBN)[3]. We present an industrially viable technique for manufacturing new classes of lightweight polymer/graphene and polymer/hBN composites with high directional thermoconductivity and tailored electrical conductivity and dielectric permittivity. Shear-induced orientation of graphene and hBN platelets developed by high shear rate injection molding leads to a significant anisotropic thermal conductivity. On the other hand, the generation of a porous structure, via SCF foaming imparts in situ exfoliation, random orientation, and interconnectivity of graphene and hBN platelets within the polymer matrix. This results in highly isotropic thermoconductivity with enhanced bulk thermal conductivity.

Polymer/GnP Composites

We developed microcellular nanocomposites containing highly exfoliated GnPs via an industrially-viable technique of melt mixing followed by SCF-treatment and physical foaming in an injection molding process. This process provided a tailored structure that effectively supported the improved thermal conductivity of high-density polyethylene (HDPE)/GnP composites. For example, the SCF-treated HDPE-17.6 vol.% GnP nanocomposites had a solid thermal conductivity of 4.13±0.12 $Wm^{-1}K^{-1}$ which was superior to the values of their solid counterparts (2.09±0.03 $Wm^{-1}K^{-1}$; *Figure 1*).

FIG. 1 *LEFT* (A) TOTAL THERMAL CONDUCTIVITY AND (B) DC CONDUCTIVITY OF SOLID AND POROUS HDPE/GNP COMPOSITES AS A FUNCTION OF THE GNP CONTENT; (C) XRD SPECTRA OF NEAT HDPE, GNP POWDER, SOLID, AND POROUS WITH 4.5 VOL.% GNP INDICATING THE GNP EXFOLIATION WITH SCF-FOAMING. (D) REPRESENTATIVE TEM MICROGRAPHS OF THE POROUS AND (E) SOLID OF THE HDPE-4.5VOL.% GNP 5 FURTHER SUPPORT THE GNP EXFOLIATION. REPRINTED WITH PERMISSION FROM [2] AND [5].

We have also demonstrated that SCF-foaming can substantially increase the electrical conductivity and reduce the percolation threshold of the HDPE/GnP composites (*Figure 1b*). The generation of a microcellular structure re-arranged the GnPs so that they were mainly perpendicular to the radial direction of the cellular growth within the cell walls. This enhanced the GnPs' interconnectivity which resulted in a significantly higher conductivity and a lower percolation threshold. For example, in addition to 26% density reduction, the percolation threshold of 19 vol.% GnP in the solid samples was sharply decreased to 7.2 vol.% GnP with the introduction of a 26% degree of foaming.

The higher thermal and electrical conductivity and the lower percolation threshold of the foamed samples, as compared to the solid counterparts, were mainly attributed to the changes in the microstructures. The generation of a microcellular structure via SCF foaming imparts in situ exfoliation, random orientation and interconnectivity of GnPs within the polymer matrix (*Figure 1c-e*). The SCF-assisted exfoliation of both GnP and hBN has been discussed in detail in our previous study[2,3,5–7].

Polymer/hBN Composites

Efficient materials for heat management in microelectronics should offer high thermoconductivity, low dielectric constant (ε') and low dielectric loss (tan δ) 8. Low ε' and low tan δ can efficiently slow down the crosstalk and capacitative coupling in high operation speed microelectronic devices, and thereby decrease the resistance-capacitance delay effect [8].

Part of our research presented a simple method of fabrication of solid and porous HDPE/hBN composites with high thermoconductivity, low ε' and ultralow tan δ is presented (*Figure 2*). The HDPE/hBN composites with tailored structures were developed through a scalable technique of melt compounding followed by injection molding. The directionally-dependent thermal transport properties of the polymer/hBN composites were further understood through X-ray tomography assessment of the internal structure of the composites which revealed an anisotropic structure in the case of the solid composites and an isotropic structure in the case of the porous composites. Due to high shear rate, induced during injection, a high level of hBN platelet orientation was generated within the polymer matrix as revealed by x-ray tomography. This structure resulted in significant anisotropic thermoconductivity in the solid HDPE/hBN composites. For instance, the in-plane thermoconductivity of the solid HDPE/23.2 vol.% hBN composites reached 10.1±0.5 $Wm^{-1}K^{-1}$, while the through-plane thermoconductivity was 0.28 $Wm^{-1}K^{-1}$. By the introduction of a small amount of porosity (10%) through physical foaming, (i) shear-induced orientation of hBN was changed into random orientation with increased local and 3D interconnections of hBN; and (ii) dispersion and exfoliation of hBN were further enhanced. This resulted in higher bulk thermoconductivity of the porous HDPE/hBN composites (10% porosity), as compared to their solid counterparts. Both solid and porous HDPE/hBN composites were highly electrically insulating with low ε' (> 3.00±0.04) and ultralow tan δ (> 0.0068 at 100 Hz).

Our research presents new routes to microscopically engineer the structures and properties of thermoconductive polymer composites with tailored electrical properties for heat management in microelectronic packaging.

Our contributions would not have been possible without our outstanding collaborative partners at University of Toronto and INSA Lyon, as well as generous financial support of NanoXplore Inc., and the Natural Sciences and Engineering Research Council of Canada (NSERC).

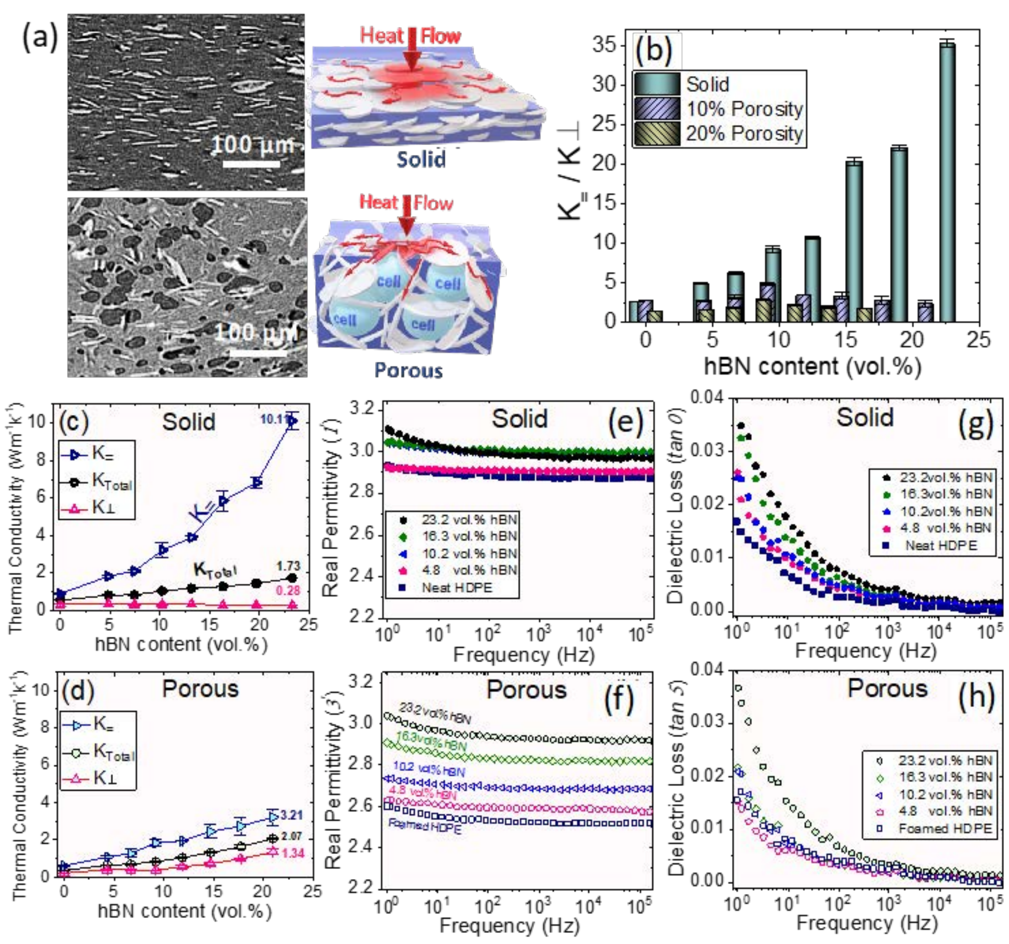


FIG. 2. (A) REPRESENTATIVE X-RAY TOMOGRAPHY OF SOLID AND POROUS (20% POROSITY) HDPE/10.2 VOL.% HBN COMPOSITE AND SCHEMATIC REPRESENTATION OF ANISOTROPIC AND ISOTROPIC HEAT DISSIPATION IN SOLID AND POROUS COMPOSITES; (B) THE $K_{=}$ / $K_{\perp}$ RATIO AS A MEASURE OF ANISOTROPY OF THE THERMAL CONDUCTIVITY FOR THE SOLID AND POROUS SAMPLES; IN-PLANE AND THROUGH-PLANE THERMOCONDUCTIVITIES OF THE (C) SOLID AND (D) POROUS SAMPLES (10% POROSITY); **ε'** OF (E) THE SOLID, AND (F) POROUS HDPE/HBN COMPOSITES. TAN **δ** (G) THE SOLID, AND (H) POROUS HDPE/HBN COMPOSITES. REPRINTED WITH PERMISSION FROM [3].

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Thermal Energy Storage Application for Space Heating by Using Adsorption of Moisture from Air

ENERGY STORAGE IS VERY IMPORTANT FOR THE implementation of renewable sources of energy, since they tend to be intermittent and their supply and demand are mostly not synchronized. For example, solar energy is abundant during the day, where it is mostly needed at night. Also, the solar energy is abundant during the summer, whereas the space heating is mostly needed in the winter. Therefore, if the renewable sources of energy can be stored when they are not needed, they can be used at other times when they are needed, at which time their sources are not available. The storage technologies would help the renewable sources of energy to be implemented more in our society. The storage can be done for a short term with charging and discharging done every day, or for a long term where charging is done in the summer and the discharging is done in the winter.

One form of energy that can be stored is the thermal energy, as heat. It can be stored when there is renewable source of energy, such as solar radiation, or when there is waste heat, and it can be used as space heating at another time.

Thermal energy storage can be carried out by using different technologies. Some examples of these technologies are:

Using sensible heat: Where the thermal energy is stored in hot water tanks, or rocks, etc. for which the heat increases the temperature of the water or the rock during the charging and when the heat is needed, it is released into the space to be heated up. There are actually some luxury houses build in Europe where there is a huge water tank in the middle of the house, in which the heat is stored.

Using latent heat: Where the thermal energy is stored by taking advantage of latent heat to melt the phase change material (PCM) at constant temperature during the charging and to solidify the same PCM at the same temperature during the discharging. Depending on the PCM, this process can be carried out at low or at high temperatures.

Using thermochemical processes: These processes take advantage of the exothermic nature of reversible chemical processes, such as adsorption or a chemical reaction. Exothermic processes release heat, which can be used for space heating. This corresponds to the discharging of the "Thermal Battery". When this process needs to be reversed during the charging of the thermal battery, heat is used from a source of solar radiation or waste heat to do the charging.

A summary of adsorption thermal energy storage systems are given by Lefebvre and Tezel, 2017[1].

At the University of Ottawa, we are working on storing thermal energy by making use of an exothermic adsorption process by adsorbing moisture from air. If moist air at room temperature is passed through a column packed with microporous adsorbent materials, such as zeolites, the water vapor would be adsorbed and this adsorption process would generate thermal energy (as can be seen in *Figure 1*) that would heat up the air carrying the moisture. This air temperature leaving the column will be much higher than the room temperature and therefore this air can be directly used for space heating. This adsorption process would correspond to the discharging of the thermal battery. When the column eventually gets saturated with water vapor, it will need to be regenerated, so that it can be used again for another adsorption cycle. This is done by reversing the adsorption process, which is called desorption. Then the source of thermal energy (obtained from solar radiation or from waste heat) is used to desorb the water vapor from the column. This desorption process would correspond to the charging of the thermal battery (see *Figure 1*) and regenerate the column to be discharged again. Many different adsorbent materials can be used for this thermal energy storage application for multiple cycles, making them good candidate materials for this application.

You can watch a video for the explanation of this process at: https://youtu.be/CaOLBCI3vMo

Prof. F. HANDAN TEZEL, PhD, P.Eng., FCIC, FEIC

Professor Tezel is a Full Professor in the Department of Chemical and Biological Engineering at University of Ottawa and a Fellow of Engineering Institute of Canada. She received her PhD from University of New Brunswick in 1986. She was the Vice-Dean, Research for Faculty of Engineering at University of Ottawa and received John Marsh Award for Excellence in Teaching. She is currently a member of the Energy Task Force for OSPE (Ontario Society of Professional Engineers), leading their Energy Storage initiative and a team leader at NESTNet (a Canada wide energy storage network). Her research interests are in thermal energy storage, as well as in gas and liquid separations by adsorption and membranes.

IMAGES COURTESY OF THE RESEARCHER

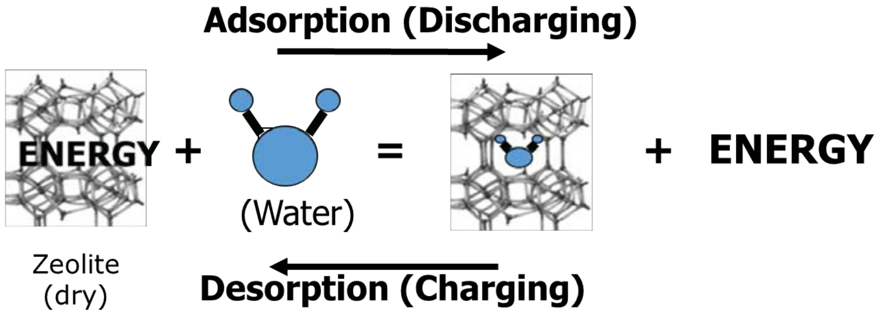

FIG. 1: FIGURE SHOWING THE REVERSIBLE NATURE OF THE EXOTHERMIC ADSORPTION PROCESS THAT RELEASES HEAT TO BE USED AS THERMAL BATTERY. ADSORPTION (DISCHARGING STEP) IS EXOTHERMIC, WHICH RELEASES HEAT. DESORPTION (CHARGING STEP) IS ENDOTHERMIC, WHICH NEEDS HEAT. ENERGY THAT CAN BE STORED BY THIS TECHNOLOGY CAN BE COMING FROM SOURCES SUCH AS SOLAR RADIATION OR WASTE HEAT.

We are currently working on increasing the energy storage density of the materials to be used as thermal batteries. We have reached an energy density of 215 kWh/m^3 with some of our adsorbent materials [2, 3]. We are also carrying out the mechanistic modeling of this unsteady process by using the mass and energy balances for the system [4]. This allows us to predict the behavior of this thermal battery system for other scenarios that we are not able to study in the lab, such as for scaling up the adsorption process for larger systems.

Some advantages of this technology are:

No hazardous chemicals are involved in the process: only water, air and earth-type adsorbents such as zeolites. Therefore, they do not cause any environmental damage to be cleaned up later as some of the electrical batteries do. They can be easily used in residential systems, commercial buildings, as well as utility scale applications.

Energy can be stored forever, as long as the column is isolated from the rest of the system and does not get into contact with moisture. This advantage does make this technology superior to some other thermal energy storage technologies, such as the ones that use sensible heat, which disappears after a while, no matter how much you insulate it. Therefore, the ones based on sensible heat can be used for short term storage solutions only, whereas the ones based on adsorption processes can be used for both short term and long term storage applications.

The process can be designed to be portable. For example, in a plant, if you have low quality waste heat that you don't know what to do with, you can store it in an adsorbent column in the back of a truck and drive the truck to the part of the plant where you would need space heating. You can also sell this heat to other neighborhoods close by. The system can be designed as small or as large as you need, depending on the charging and the discharging capacities required.

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New Guidelines and Procedures for CSME Technical Awards

At its October 2019 meeting, the CSME Board of Directors approved a set of Guidelines and Procedures for the new Technical Awards established in June 2019. The new guidelines will also apply to the current CSME Jules Stachiewicz Medal, which is a biennial Technical Award recognizing outstanding contributions to the field of heat transfer in Canada.

Technical Awards Description

The CSME Technical Awards were created to be prestigious awards that recognize truly outstanding achievements in broad technical disciplines in Canada, specifically: Heat Transfer, Fluid Mechanics, Solid Mechanics, Manufacturing, Mechatronics, and Emerging Technologies. In October 2019, the Board agreed to have five new medals minted, each corresponding to one of the disciplines. The technical medals are to be awarded (potentially) once every two years: nominations for Fluid Mechanics, Solid Mechanics and Manufacturing awards were considered for the first time in October 2019 (for potential award at the 2020 CSME Congress in Charlottetown, PEI) but none were selected. The awards for Heat Transfer (Stachiewicz Medal), Mechatronics and Emerging Technologies will be considered for first-time remittance at the 2021 CSME Congress in Edmonton, AB (submission deadline is 30 September 2020). This cycle will repeat in the fall every 2 years and each winner will be expected to present a plenary lecture at the subsequent annual Congress.

Eligibility Criteria

The outstanding achievement of each Technical award winner may be in the form of a single contribution which is groundbreaking, or a body of work which is widely recognized as contributing to the discipline in an exceptional way. Nominees must be members of the CSME. If no nomination is submitted in a given year that meet these standards of quality, then no award will be made that cycle.

Nomination Package

For details on what constitutes a complete nomination package, please refer to the Guidelines that are published on the website (csme-scgm.ca/awards).

Deadlines

Nominations for Heat Transfer (Jules Stachiewicz), Mechatronics and Emerging Technologies Award medals must be received by midnight on 30 September 2020.

Nominations for Fluid Mechanics, Solid Mechanics and Manufacturing Award medals must be received by midnight on 30 September 2021.

Thermal-sprayed Heating Coatings and Moving Boundary Phase Change Problems

DR. ANDRÉ McDONALD, PhD, BS LAW, P.Eng., FASM, FIMMM, MCSME

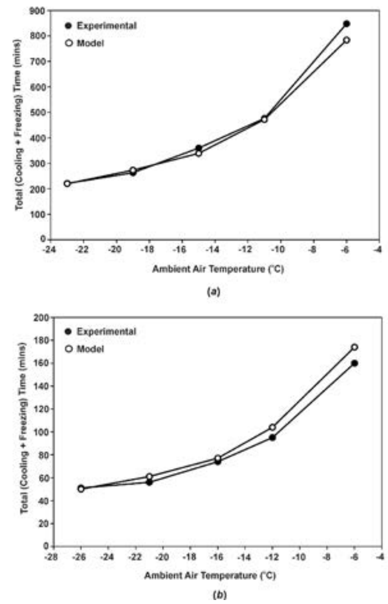
Dr. McDonald is currently a Professor and the Associate Chair (Research) in the Department of Mechanical Engineering at the University of Alberta. He received his PhD from the University of Toronto in 2007, under a collaborative research project with the National Research Council Canada in Boucherville, Québec. His research expertise is in the fabrication, development, performance assessment, and modelling of thermal- and cold-sprayed coatings for wear and erosion resistance, heating, and structural health monitoring. Professor McDonald has received several awards including the President's International Fellowship Initiative Award from the Chinese Academy of Sciences, the Mentorship Award from the Faculty of Engineering (University of Alberta), the Composites Conference Best in Track Technical Paper Award for Manufacturing, and the Association of Professional Engineers and Geoscientists of Alberta's Early Accomplishment Award. Among his service contributions to the profession, he is the Lead Editor of the Journal of Thermal Spray Technology, *Chairman of the Canadian Cold Spray Alliance, and President of the ASM Thermal Spray Society Board.*

IMAGES COURTESY OF THE RESEARCHER

PIPE DAMAGE DUE TO FREEZING OF CONTAINED liquid is widespread and costly in industrial practice, resulting in over $4 billion in damage over the last decade. Problems due to the solidification of liquids in pipes occur in a variety of technical areas, including residential and industrial plant applications. In the Oil & Gas industry alone, there have been instances where tremendous pressures within pipes due to liquid freezing have resulted in explosive ruptures, which caused damage to property, injuries to workers, and in some tragic cases, fatalities. Many fundamental studies have focused on the use of quasi-analytical or numerical methods to describe the solidification of liquids in pipes. However, the use of numerical methodologies and verification through case studies makes transfer and use of the results in industry settings difficult. Furthermore, little work has been conducted to estimate freezing time during the solidification process in practical areas of interest. This has resulted in decisions in industry based solely on past experience and technician intuition for fairly important and potentially risky safety issues.

Professor André McDonald and his team in the Department of Mechanical Engineering at the University of Alberta, along with collaborators at Cenovous Energy Inc. in Calgary, Alberta, have addressed this problem by studying freezing in pipes and developing flame-sprayed coatings-based resistive heating elements to mitigate or prevent freezing. They first developed one-dimensional transient heat conduction models from first principles to estimate the freezing time of quiescent water in unpressurized horizontal pipes under free and forced convection conditions. Phase change problems in heat conduction are typically studied for situations where semi-infinite extent can be assumed. The novelty of the models stemmed from use of the separation of variables method for a finite length-scale heat conduction problem in a cylindrical pipe that was applied to moving or free boundary problems to predict phase change phenomena. The model predicted the total freezing times in 50.8-mm nominal diameter Schedule 80 steel pipes to within 8% of the experimentally measured freezing times (*see Figure 1*). These results allowed for extension of the study to develop predictions of freezing time for quiescent water in residential and commercial building applications for bare and insulated pipes. In addition to providing information on the freezing time of water in pipes, the model and its outcome can be integrated into industry or building system software to predict the time at which pipes will be completely blocked by ice and risk bursting damage.

FIG. 1: TOTAL FREEZING TIME VERSUS TEMPERATURE FOR WATER IN 50.8-MM NOMINAL DIAMETER SCHEDULE 80 STEEL PIPES UNDER (A) STAGNANT AND (B) FORCED (31 KM/H) AMBIENT AIR CONDITIONS (SOURCE: A. MCDONALD, B. BSCHADEN, E. SULLIVAN, R. MARSDEN, MATHEMATICAL SIMULATION OF THE FREEZING TIME OF WATER IN SMALL DIAMETER PIPES, *APPL. THERMAL ENG.*, 73, 2014, 140 – 151.)



Flame-sprayed coatings that act as resistive heating elements were developed to mitigate or prevent freezing of water in pipes. Flame spraying is a process in which heat from the combustion of fuel gases is used to melt and accelerate micron-sized powder particles to fabricate coatings. The coatings tend to adhere well to the surfaces on which they are deposited ("the substrates") and are very thin, thus minimizing material costs. Nickel-chromium alloy was deposited as a coating and electrical current was passed through the material. The flow of electrons produced heat energy by Joule heating. Alumina was deposited to serve as an intermediary dielectric layer between the nickel-chromium coating and the steel to avoid short-circuiting of the coating during Joule heating. This 300-µm thick coating system (see Fig. 2a) was able to melt ice in a fully frozen 50.8-mm nominal diameter, 305-mm long Schedule 40 steel pipe in less than 80 minutes (see Fig. 2b). A low voltage of 10.6 V and current of 3.8 A was applied across the coating.

Resistive heating coatings present advantages over conventional pipe heat tracers or heating cables. Given the good adhesion between the coatings and the substrates, the thermal contact resistance between the two surfaces is reduced,

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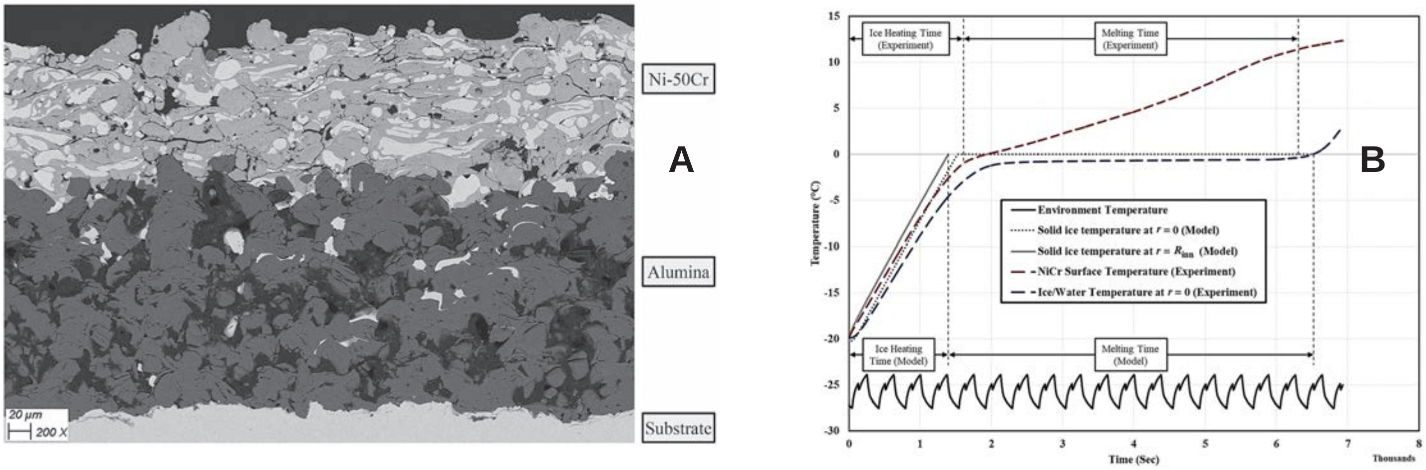


FIG. 2: (A) FLAME-SPRAYED COATING-BASED HEATING SYSTEM AND (B) TEMPERATURE TRACE OF COATING SURFACE AND ICE/WATER MIXTURE IN PIPE. (SOURCE: M. REZVANI RAD, A. MCDONALD, MATHEMATICAL SIMULATION OF HEATING AND MELTING OF SOLID ICE IN A CARBON STEEL PIPE COATED WITH A RESISTIVE HEATING SYSTEM, *INT. J. HEAT MASS TRANSFER*, 138, 2019, 923 – 940.)

improving heat transfer from the coatings to the frozen material in the pipes. Coatings can be easily deposited on irregularly shaped devices such as valves. This allows for heating protection of those devices that may be difficult to protect with conventional heating solutions. Moving forward, coating-based heating elements will be advanced for applications on wind turbine blades as de-icing/anti-icing systems. Given their ability to conduct charge, they will also be multi-functionalized to serve as piezoresistive sensors in structural damage detection protocols for the surfaces that they heat.

Call for Nominations – 2021 EIC Awards

The Engineering Institute of Canada (EIC) is pleased to announce that it is currently accepting nominations for its 2021 senior awards and EIC fellowship inductees.

The deadline for nominations is midnight, 15 November 2020 for awards to be remitted at the EIC Gala in April 2021.

The senior awards of the EIC are the highest distinctions made by the Institute and are awarded to deserving members of its technical societies, including the Canadian Society for Mechanical Engineering:

- SIR JOHN KENNEDY MEDAL for outstanding services rendered to the engineering profession, or of noteworthy contributions to the science of engineering, or to the benefit of the Institute.
- JULIAN C. SMITH MEDAL for achievement in the development of Canada.
- K.Y. LO MEDAL for significant engineering contributions at the international level.
- JOHN B. STIRLING MEDAL for leadership and distinguished service at the national level within the Institute and/or its Constituent Societies.
- CANADIAN PACIFIC RAILWAY ENGINEERING MEDAL for many years of leadership and service by members of the Societies within the Institute at the regional, branch and section levels.
- EIC FELLOWS are inducted for excellence in engineering and services to the profession and to society.

Nomination rules and form can be found on EIC's website: eic-ici.ca/honours_awards

About the EIC

Founded by Royal Charter in Montreal in 1887 as the Canadian Society of Civil Engineers with the mandate to disseminate technical information and experience, the society was renamed by Parliament in April 1918 as the Engineering Institute of Canada. In its first century, the EIC functioned as a learned society with members from various engineering disciplines. It is now a federation of twelve technical societies representing the main engineering disciplines and whose mandates remain the dissemination of technical knowledge and experience and the maintenance of high standards for engineering practice in Canada.

Contact: Guy Gosselin, EIC Executive Director. ggosselin.eic@gmail.com / www.eic-ici.ca

Novel Heat Transfer Related Research from the Faculty of Engineering and Applied Science at Ontario Tech University

FIG. 1: ACE AND CERL, TWO UNIQUE RESEARCH FACILITIES IN THE FACULTY OF ENGINEERING AND APPLIED SCIENCE AT ONTARIO TECH UNIVERSITY.

SINCE THE INCEPTION OF ONTARIO TECH UNIVERSITY, ENERGY HAS BEEN AT THE FOREFRONT of our research activities within the Faculty of Engineering and Applied Science. In an era where researchers around the world are searching for more efficient means of transportation and sustainable energy solutions, our faculty members have been exploring the heat transfer and thermal management options for various energy and electrochemical systems and applications. More recently, our research efforts include batteries and robots, where thermal management is recognized as being an important area of research, as it is necessary to better manage thermal loads and keep system performance at the desired level. One example is the thermal management of batteries in electric vehicles. While electric vehicles are currently leading the way as the most promising sustainable mode of transportation, it is well known that the performance of the batteries that make this possible is sensitive to temperature. A battery's performance is considered at 100% capacity at a temperature of 27oC and can lose upto 50% of its capacity at a temperature of -18oC. Therefore, advancements in electric vehicles are critically tied to the development of effective thermal management techniques. Another area in which we are developing thermal management in robotics. Robots suffer from the same issues as batteries, as they are commonly used as power source. Furthermore, robots have certain temperature sensitive sensors that require above freezing temperatures to operate. There are, however, critical issues stemming from heat transfer, such as thermal management and moisture control, that must be addressed before we can see a safe and seamless integration of robots into our society.

At this time, our researchers are doing crucial and cutting-edge research in both of these areas, as innovations in these areas will help enable the commercialization of both electric vehicles and robots. The main research hubs for heat transfer related research at Ontario Tech University are located within the Faculty of Engineering and Applied Science and are considered a unique advantage. They are the Clean Energy Research Lab (CERL) and the Automotive Centre of Excellence (ACE) (*as shown in Figure 1*). The CERL is a large stakeholder in this research, being the primary place where the experimental research is being carried out, ranging in areas from hydrogen production and fuel cell technologies, to the development of thermal energy storage systems and phase change materials. There is also research taking place in the climate control chambers of our Automotive Center of Excellence (ACE), where the thermal management of electrochemical devices and robots are being investigated and tested.

Prof. HOSSAM KISHAWY, PhD, P.Eng., FCSME, FEIC, FASME

Dr. Kishawy, Interim Dean of the Faculty of Engineering and Applied Science at Ontario Tech University, is an internationally renowned researcher in the area of advanced manufacturing and the modelling of mechanical systems. He is an elected Fellow of the the Canadian Society for Mechanical Engineering, the Engineering Institute of Canada, and American Society of Mechanical Engineers.

IMAGES COURESTY OF THE RESEARCHER

Here are a few examples of our cutting-edge research activities within the field of robotics. One specific area we are investigating is the heat transfer performance of various insulating materials for robots, which has recently been published elsewhere[1]. This research project is unique, as researchers are investigating how to mitigate the challenges faced in thermal managing robots. The project proposed and investigated ten potential options of thermal management, including phase change materials, air/liquid systems, thermoelectric generators, heat pipes, thermal insulation, and interface materials (*Figure 2*).

A thermal management system for air heating/cooling was experimentally tested to explore the system performance at high and low temperatures using different thermal insulating materials such as fiberglass, stone wool, and extruded polyurethane. The performances of the thermal insultators will be defined under the first and second law of thermodynamics. The efficiency is defined as the net heat gain/loss rate divided by the total heat generation rate. The insulating material of fiberglass offered maximum energy efficiency of 48.1%, stone wool offered 47.3%, and extruded polyurethane offered 32% energy efficiency. The maximum exergy efficiency of 23.6% was offered by stone wool, followed by 20.73% offered by extruded polyurethane and fiberglass offered exergy efficiency of 18.19% at 40°C temperature. The insulating material of stone wool offered maximum energy efficiency of 49.9%, followed by fiberglass, which offered 47.82% and extruded polyurethane offered 31.1% energy efficiency at the temperature of -25°C. Furthermore, the energy efficiency of the air heating thermal management system for air heating offered the energetic and exergetic efficiencies of 27.3% and 3.6% at the temperature of -25°C.

Our researchers have also been conducting extensive research on the design, development, analysis, modeling, simulation and experimental investigation of novel battery thermal management systems for electric and hybrid electric vehicles (*see Figure 3, which shows future ammonia-based HEV vehicle that runs using heat from ammonia combustion and electrical energy stored in batteries,* i.e.[2]), focusing on the ther-

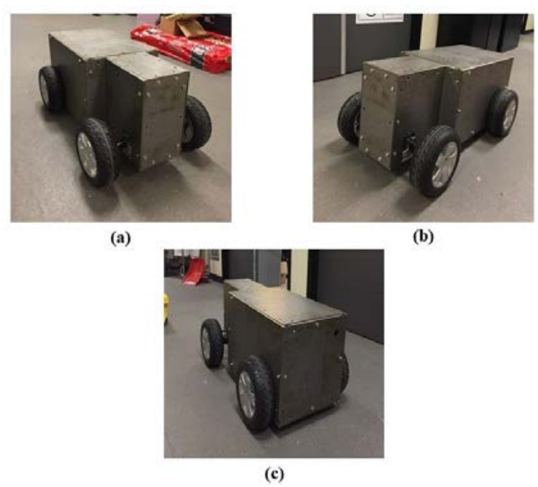


FIG. 2: THE TESTING ROBOT (LEFT VIEW) AND WITH THE FIBERGLASS COVER (RIGHT VIEW) IN THE CLIMATIC CHAMBER

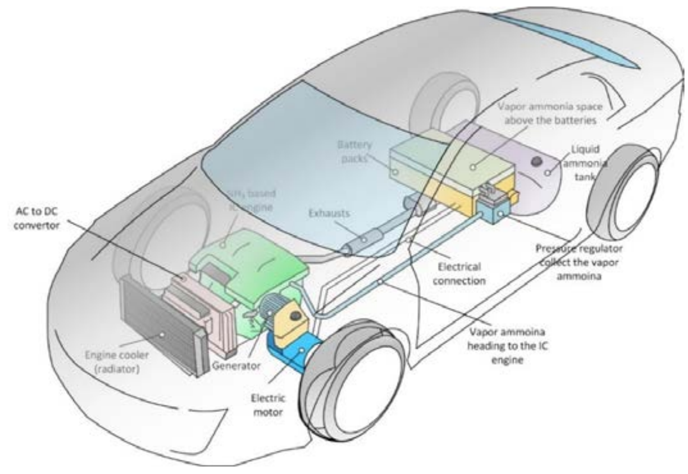


FIG. 3: SCHEMATIC DIAGRAM OF THE AMMONIA-BASED FUTURE HYBRID ELECTRIC VEHICLE IN WHICH THE PROPOSED BOILING BASED BATTERY COOLING SYSTEM IS EMPLOYED [2, 3].

mal management in the lithium-ion batteries to control the battery packs operating temperature, which was directed to the hybrid electrical and electrical vehicles. The electrochemical models were also presented, analyzed to investigate the thermal performances[3,4]. The proposed thermal management systems were investigated through different performance parameters in each battery and throughout the battery pack and maximum temperature distribution in battery packs. The results of this thesis study revealed that the cylindrical battery packs offered better performance as compared with the prismatic battery packs. The designed pool system reduced the maximum battery temperature from 28% - 40% dependent on fuel type by covering 30% of battery height. The designed pool system was required to cover 80% battery height to achieve 28% - 40% maximum temperature drop in the prismatic battery without cooling. The tube-based prismatic battery packs system offered the best performance in the case of an aluminum cold plate fully filled with coolant which helped in maintaining the battery temperature. The response time offered by the proposed designs was found to be around 10 times faster as compared with the air and liquid systems in the literature. In comparison with literature, the pool-based design revealed 1.7% of cycle time, which is nearly 17% cycle time in the case of the mini-channel cold-plate cooling design. A cycle is defined as the period of time of charge or discharge from a state of charge (SoC) of 20% to 80%, and vice versa.

Among numerous studies conducted by faculty members of the Faculty of Engineering and Applied Science, this particular study[5] designed a sensible thermal energy storage system for effective energy management systems and conducted the thermodynamic analysis considering the charging and discharging of thermal energy storage model. They investigated the minimum and maximum temperatures for charging and discharging using the temperature function, maximum heat flow capacity for charging and discharging, energy flow function for charging and discharging and the thermal energy storage cycle expression. The achieved results revealed that the charging temperature was increased with the rise in the input energy flow rate, and discharging temperature increased with the drop-in outlet energy flow rate. In another study, they performed the energy analysis on the grid integrated thermal energy storage systems. The researchers[5] proposed different configurations for thermal energy storage systems and investigated the significant parameters of recovered energy and discharging temperature. Furthermore, they investigated the characteristics of thermal energy storage configurations as functions of properties and developed the functions for discharge energy and discharge temperature for thermal energy storage designs. The results revealed that parallel thermal energy storage (TES) design configurations behaved independently. It is important to note that the parallel configuration technically combines two heat storages that are independent of each other. These two units of a TES system only share the energy source. Two heat storages in a parallel configuration can have different storing media with different properties. They can also have different sizes. The TES can start storing heat at various initial temperatures. Thus, every energy storage releases different amounts of heat at various temperatures to the district energy system. This offers a flexible and more efficient operation. These research and development studies were composed of different types of storage media and different sizes with no initial temperature restriction while in the series configurations. The initial temperature of the latter TES system was comparable with the discharge temperature of prior TES, but no size restriction was discovered in the series configurations.

In a separate study, which was conducted by[6] as the axial bed-to-wall heat transfer investigation of circulating fluidized bed combustor, which achieves the combustion through a circulating fluidized bed type unit, particularly for coal combustion in order to reduce the emissions and make the combustion more environmentally benign. This study covered a comprehensive numerical heat transfer modeling. The axial heat transfer coefficients were projected for three different profiles of axial voidage to explore the effect of time, voidage, fixed and initial annulus, and bed temperature and gaps between solid particles and wall. A 2D thermal model was proposed for the approximation of axial heat transfer values. The results of this study revealed that both horizontal and axial particle concentrations affected the axial heat transfer, initial bed temperature provided with end heat transfer limits, annulus region offered high thermal energy as compared to the core and a particle-free zone tends to decrease the axial heat transfer up to 25%. This particular study[7] was focused on the heat transfer study on molten salt droplets. A room of improvement was found in the thermochemical Cu-Cl cycle by recovering the heat, which proposed the system to be more efficient. This study presented an analytical model to recover the heat from molten cuprous chloride by employing different gases namely; helium, nitrogen and argon. The results of this study showed better heat transfer performance using helium gas as compared with other gases. Another study[8] conducted a study on the direct-contact heat transfer from droplets of molten salt in thermochemical hydrogen production cycle. The room of improvement was found in the thermochemical Cu-Cl cycle by recovering the heat through solidifying or cooling the molten salt leaving the thermolysis reactor to make the reaction more efficient. A predictive model was proposed in this study employing the heat recovery from molten cuprous chloride and using it to yield superheated steam. The results revealed that heat transfer could be increased by a reduction in droplet size, which will reduce the height requirement of the heat recovery system.

In conclusion, both Clean Energy Research Lab (CERL) and the Automotive Centre of Excellence (ACE), have been at the forefront of innovation in the field of thermal management of robots, batteries and other electrochemical devices. Both CERL and ACE have immensely contributed new and novel techniques for thermal management in various applications that include electrochemical devices and robots. There are other projects under progress in the Faculty of Engineering and Applied Science at Ontario Tech University that span from thermal energy storage to renewable energy and heat transfer.

Article references page 22

SPOTLIGHT ON NEW FACULTY

Research highlights from new faculty members from across Canada

Interested in being featured?

Contact the editors:
prezai@yorku.ca & secanell@ualberta.ca

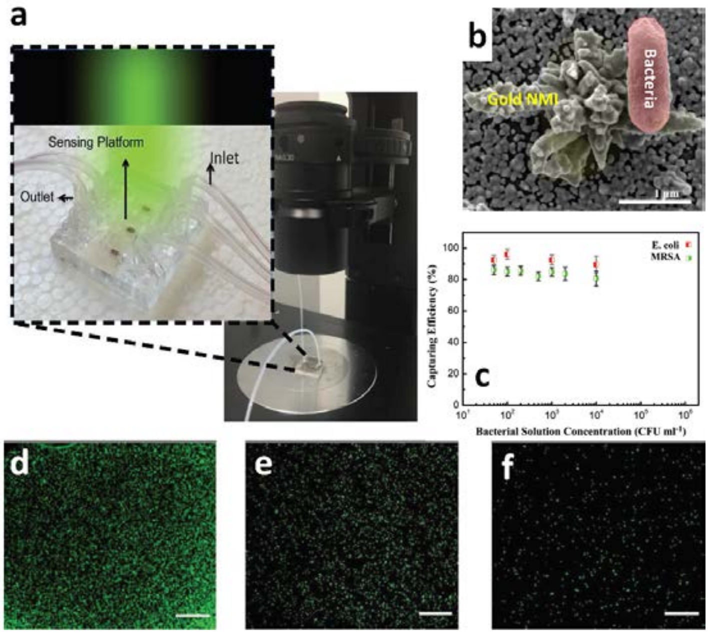


FIGURE SHOWS THE FINAL NANOSTRUCTURED FLUIDIC DEVICE UNDER OPERATION AND THE RESULTS A) EXPERIMENTAL SETUP AND BACTERIA CAPTURING MODULE. INTEGRATED FLUIDIC DEVICE CONNECTED TO SYRINGE PUMP UNDER FLUORESCENCE MICROSCOPE. B) TOP-VIEW SCANNING ELECTRON MICROGRAPH OF E. COLI BACTERIA CAPTURED ON A HIERARCHICAL 3D GOLD NMI DETECTION PLATFORM. C) BACTERIA CAPTURE EFFICIENCY OF INTEGRATED NANOSTRUCTURED MICROFLUIDIC MODULE AT DIFFERENT COUNTS. FLUORESCENCE IMAGE **OF D) 106 CFU ML−1, E) 104 CFU ML−1, AND F) 103 CFU ML−1 OF MRSA ON THE HIERARCHICAL** 3D GOLD NMI DETECTION PLATFORM.

McGill University Dr. Sara Mahshid

Nanostructured fluidic devices based on 2D and 3D nanomaterials

Mahshid lab in the Department of Bioengineering at McGill University is developing new integrated devices via synergistically combining nanostructured materials with micro/nanofluidic sample delivery systems and molecular diagnostic assays. The research aims to develop automated platforms for rapid and accurate determination of disease states, as well as assessment of the evolution of disease and the molecular hallmarks of therapeutic resistance. Diagnostics of disease at the point of need, in particular at early-stages, requires dynamic manipulation of a small number of target molecules in unprocessed body fluids. In Mahshid Lab, we investigate fabrication of novel 2D, 3D nanostructured platforms, integration of nanostructures with fluid sample delivery and biological assays (based on DNA/antibody), and implementation of the final prototypes for detection of pathogens[1-3], small molecules[4,5] and cancer biomarkers such as extracellular vesicles (EVs). In the context of diagnostics, we investigate electrical and optical read-out systems based on electrochemistry, colorimetric, fluorescent microscopy and Raman Spectroscopy. Our research at McGill University is highly translational and is supported through federal and provincial funding agencies as well as internal funding from the Faculty of Engineering and Medicine. In close collaboration with clinical researchers at McGill University Health Center (MUHC), Lady Davis Institute at Jewish General Hospital (LDI) and in partnership with industries across Canada, we develop automated and portable tools that can be used for in-field testing or as accessories to the diagnostics platforms in hospitals and clinics.

In particular, Mahshid lab has developed a new nanostructured platform based on hierarchical 3D gold nano/micro islands (NMIs) that are favorably structured for direct and probe-free capture of bacteria in optical and electrical sensors[1,3]. We employed lithography and electrochemical deposition techniques to integrate the NMIs with a microfluidic sample delivery. The nanostructured microfluidic device has been successfully implemented for rapid and quantitative detection of fluorescently labeled bacteria such as Escherichia coli and methicillin-resistant- Staphylococcus aureus with average efficiency of 93% in a wide linear range of 50- 10^4 CFU/mL[1, 2]. In addition, we successfully implemented the nanostructured fluidic device for label-free impedimetric detection of bacteria in dilutions as low as 20 CFU/mL[3]. This rapid (10 min turnaround time) and label-free diagnostic approach has already attracted interest from clinical researchers at MUHC and industrial partners for translation to remote areas for detection of parasites. In continuation of the work, Mahshid lab is developing a novel nanostructured fluidic device with ultrasensitive color-changing characteristics in different media (United States provisional patent 63/021,191). The prototype has been tested successfully for rapid phenotypic profiling of antibacterial susceptibility with average turnaround time of 20 min as opposed to time-consuming standard test methods. With the support from McGill Interdisciplinary Initiative in Infection and Immunity (MI4), the colorimetric assay is now implemented for specific detection of SARS-CoV2 via one-step amplification of the viral RNA. The prototype can potentially simplify testing of SARS-CoV2 RNA, making it easier and cheaper to manufacture tests, and providing faster results for diagnostics of COVID-19.

Mahshid Lab gathers researchers and trainees from around the globe with different educational backgrounds and levels of expertise composed of PhD, MSc, undergraduate and postdoc. In such a diverse environment, we develop multidisciplinary skills in lab-on-chip technologies, biosensors and in-vitro assessment of drugs activity. We are always looking for talented and motivated students interested in interdisciplinary research to join our team. In our continued effort in support of Canada's response to global health challenges, we always welcome new initiatives, collaboration with clinical researches and partnership with industries across Canada.

Article references page 22

Dr. SARA MAHSHID, PhD

Dr. Mahshid is an Assistant Professor in the Department of Bioengineering at McGill University and an associate member of Biomedical Engineering in the Faculty of Medicine. She is the director of BioNano Medical Device Laboratory (mahshidlab.com) with a joint affiliation with Biological and Biomedical Engineering (BBME) program at McGill University. She is also a full member of McGill Interdisciplinary Initiative in Infection and Immunity (MI4), McGill Sustainability Systems Initiative (MSSI) and Trottier Institute for Sustainability in Engineering and Design. She received MSc and PhD degrees in Materials Science and Engineering from Sharif University of Technology. She held postdoctoral positions with Génome Québec Innovation Centre and then Faculty of Pharmacy at the University of Toronto. In the last three years, Dr. Mahshid has established an interdisciplinary research program that combines expertise in nanomaterials based biosensing, nano/microfluidics and molecular diagnostics with strong focus on translational research. She is leading interdisciplinary projects such as NFRF-Exploration and MI4-ECRF between faculties of Engineering and Science at McGill and MUHC and LDI health centers in Montreal. Her research has been featured by media outlets including McGill Newsroom, Radio Canada, Engineering Newsroom and MI4 Newsletter.

University of Alberta
Dr. Arman Hemmati

Turbulent flow dynamics: innovation through fundamental principles

Innovation and technological development are in the forefront of addressing major global challenges including climate change and energy sustainability. To this end, fundamental engineering research is critical to provide the necessary tools, knowledge and methodologies for the development of innovative, out-of-the-box technologies in different industries, such as energy, medicine, transportation (ground, aviation and marine), and disaster mitigation. This is the research policy driving Alberta Computational Fluid Laboratory (A-CFL), under the direction of Dr. Arman Hemmati. This lab consists of a diverse set of extraordinary scholars with backgrounds in engineering, the sciences and medicine. Such a wide range of knowledge, skills and training enables Dr. Hemmati and his team to address a diverse set of engineering problems using Computational Fluid Dynamics (CFD) with a specific expertise in turbulent wakes and shear flows. Dr. Hemmati's research falls into three main categories: Energy, Transportation and Medicine.

Dr. Hemmati served as an Official Observer for the United Nation Framework Convention on Climate Change (UNFCCC) to assist in drafting of the Paris Climate Accord in 2015. It was in these meetings that he identified, first-hand, the main challenges that we face as a global community to effectively address the existential threat of climate change. This eye-opening experience further energized Dr. Hemmati's vision to advance fundamental knowledge in fluid mechanics and turbulence in order to develop tools and technologies that facilitate climate change mitigation and adaptation.

CFD is a powerful tool that enables detailed analyses of complex fluid flow processes for better design and operation of energy systems. Dr. Hemmati has received several federal, provincial, and industrial grants, such as Canada First Research Excellence Fund, NSERC, Alberta Innovates Climate Change Innovation Technology Framework, and Imperial Research Award, to study the development of alternative energy systems. Particularly, Dr. Hemmati's team focuses on micro-scale and macro-scale energy extraction and transportation. His current research projects related to future energy systems include the following:

(1) Underwater hydrodynamics of swimming fish with applications in energy harvesting.

(2) Aerodynamics of sharp-edge bluff-bodies with applications in wind and solar energy.

(3) Viscous pipeflow dynamics with applications in heavy oil transportation.

(4) Steam-Assisted Geothermal Power Extraction (SAGPE) with applications in geothermal power.

(5) Forest fire modeling with application in forest fire mitigation in collaboration with Natural Resources Canada..

Autonomous vehicles are the future of transportation, and their perfection requires better understanding of the flow dynamics around them. This includes identifying adverse fluid behaviors as well as means to address them to gain higher efficiency, better stability and lower

. . . continued page 22

Dr. ARMAN HEMMATI, *PhD, MCSME*

Dr. Hemmati is an Assistant Professor in the Department of Mechanical Engineering at the University of Alberta. He received his BSc (2011) and PhD (2016) in Mechanical Engineering from the University of Calgary, winning a number of prestigious federal and provincial fellowships. He later joined the Gas Dynamics Laboratory at Princeton University as an NSERC Research Fellow. He is currently the Director of Alberta Computational Fluid Laboratory and the co-chair of the Fluid Mechanics Symposium at the 2020 CSME Congress. His current research is on turbulence and turbulent wake dynamics using computational fluid dynamics. Particularly, he explores the fundamental features of turbulent flows using computational simulations to facilitate innovative technology developments.

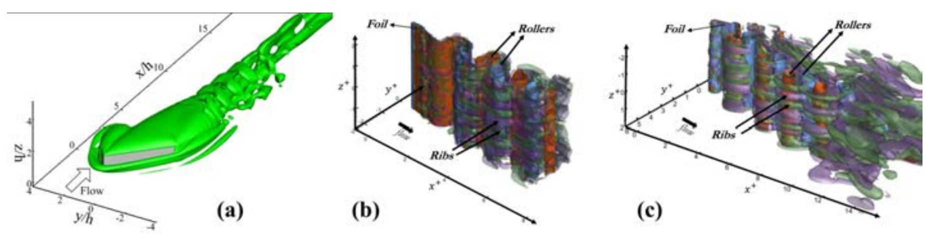


FIG. 1: THE UNSTEADY WAKE DYNAMICS OF (A) A LONG-CYLINDER (LARGE DEPTH-RATIO) REPRESENTING A BUILDING; (B) AN OSCILLATING FISH TAILFIN THAT GENERATES LARGE THRUST; (C) AN OSCILLATING FISH TAILFIN THAT RESULTS IN HIGH EFFICIENCY (PREPARED BY ARASH ZARGAR AND SUYASH VERMA).

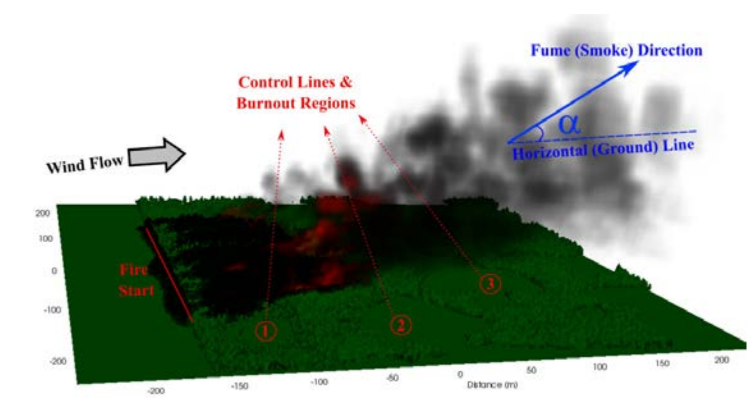


FIG. 2: THE SIMULATIONS OF A CONTROLLED FOREST FIRE USING FIRETEC IN COLLABORATION WITH NRCAN AND LOS ALAMOS NATIONAL LABORATORY TO DETERMINE HOW CONTROL LINES AND BURNOUT REGIONS AFFECT THE DIRECTION OF FOREST FIRES, SMOKE MITIGATION AND SIZE OF THE BURNT AREA (PREPARED BY GINNY MARSHALS).

Western University
Dr. Emily Lalone

Innovations in Biomechanics, Imaging and Clinical Engineering

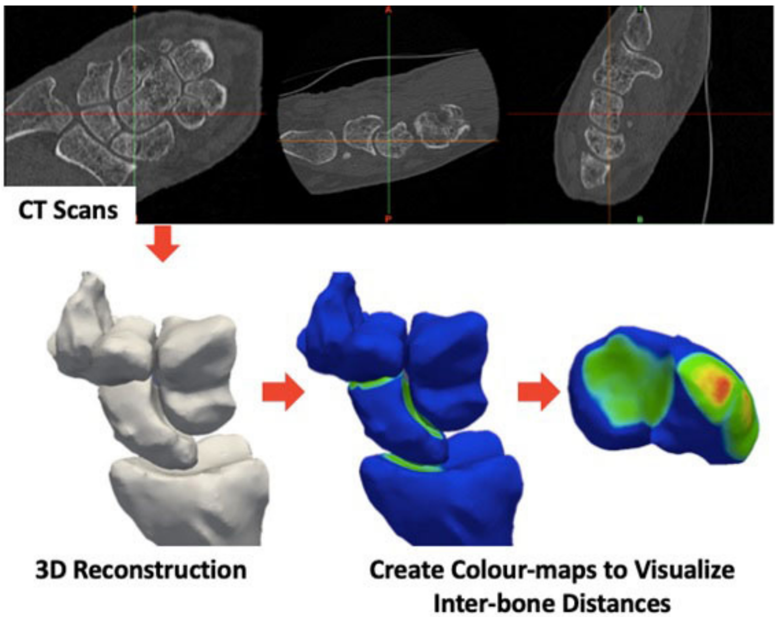


FIG. 1: BILATERAL CT SCANS ARE ACQUIRED OF PATIENTS AND USED TO CREATE 3D MODELS. JOINT CONGRUENCY IS MEASURED BY CALCULATING 3D JOINT SPACE AND CAN IS VISUALIZED USING CONTOUR MAPS.

Dr. EMILY LALONE, PhD

Dr. Lalone is an Assistant Professor in the Department of Mechanical and Materials Engineering Department at Western University. Dr. Lalone is the director of the Human Biomechanics Laboratory at Western University. Her research interests integrate biomechanics and medical imaging to model hand and upper-limb motion.

The economic cost of musculoskeletal (muscle+skeleton) disorders in Canada has been estimated to be +$7 billion/year and includes in-patient, day surgery and outpatient emergency department expenditures. Upper extremity disorders (hand and upper limb) in particular are a major problem in modern society. Not only do limitations in function have a huge impact on patients themselves and on their quality of life, but work-related musculoskeletal disorders can result in a high compensation cost and many lost workdays.

The human hand and upper limb are the most frequently used regions of the body during activities of daily living, during recreational and vocational tasks. A restriction in the movement of the hand may result in loss of function and decrease in quality of life. Currently, there is limited knowledge of joint movement patterns when people are at work, rest and play. Understanding how people use their joints is critical to our increased understanding of basic biomechanics and imperative to understand the key factors that inhibit function after injury to target interventions.

Dr. Lalone joined the Mechanical and Materials Engineering Department at Western University in January 2017. Funded partially by the National Science and Engineering Research Council of Canada (NSERC), Dr. Lalone has developed a research program in collaboration with the Roth|McFarlane Hand and Upper Limb Centre which develops quantitative tools and techniques to characterize upper extremity functional performance during complex tasks and to characterize injury mechanisms using a combined experimental and computational approaches.

Dr. Lalone's expertise is in in vivo biomechanics, musculoskeletal (MSK) imaging, orthopedics and rehabilitation. Her program is interdisciplinary and is at the intersection of biomedical engineering and medical sciences. She is currently developing a large 4DCT (3D computed tomography + time) imaging database consisting of patients who recently fractured their wrist to develop image-based biomarkers of joint trauma and arthritis. Currently, wrist fractures are imaged using 2D planar radiographs (x-rays) to monitor the fracture reduction and indicate surgery. While wrist fractures are common, it is not currently known which patients will end up with permanent disability and which patients will heal in 6-8 weeks and regain function. There are currently no red flags to indicate to the surgeons which trajectory their patients are likely to follow. This is partially a result of the 2D and static projection image offered by the x-ray. However, using 4DCT, Dr. Lalone's research group is able to fully characterize how the fracture is limiting the range of motion and altering the joint loading. She is now using deep learning algorithms to provide comprehensive pre-surgical decision making and forecasting for post-surgical monitoring. Using these image-based and computer driven mathematical approaches, her research group can use comprehensive clinical information to predict different clinical situations. With these findings, Dr. Lalone is in a position to significantly contribute to the creation of safer and more appropriate clinical practice guidelines to prevent chronic musculoskeletal dysfunction, pain and disability and aid in the development of novel diagnostics for MSK injury.

Concordia University
Dr. Farjad Shadmehri

In-situ Manufacturing of Thermoplastic Composites Using Automated Fiber Placement (AFP) Technique

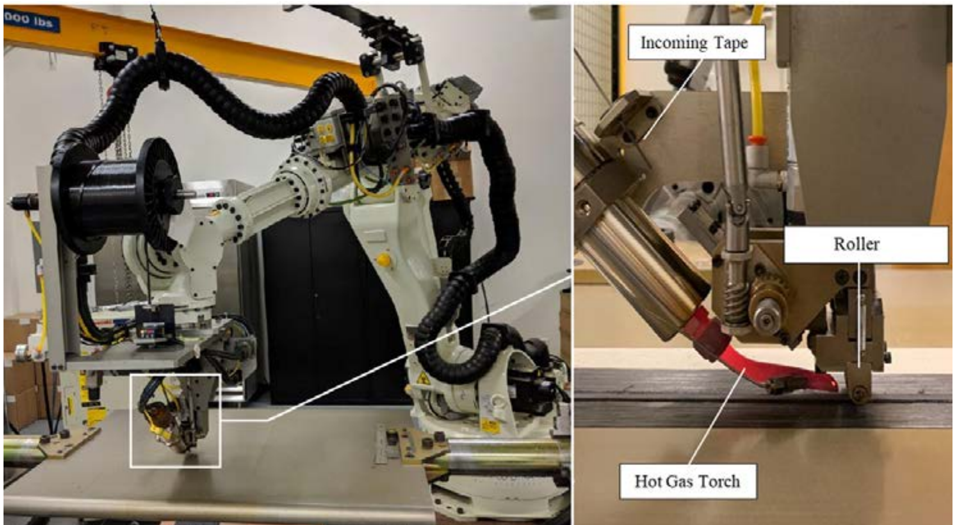


FIG. 1: AUTOMATED FIBER PLACEMENT (AFP) LAB AT CONCORDIA CENTRE FOR COMPOSITES (CONCOM)

Dr. FARJAD SHADMEHRI, PhD, P.Eng.

Dr. Shadmehri joined Department of Mechanical, Industrial and Aerospace Engineering at Concordia University in 2018 at the rank of Assistant Professor. Prior to joining Concordia, he worked at National Research Council Canada (NRC) as a research officer, structural integrity and at Bombardier Aerospace in an R&D group called "Aerostructure & Technology Development" where he invented a novel system for inspecting composite parts made by Automated Fiber Placement (AFP) called "Laser-Vision Inspection System and Method". Dr. Shadmehri earned his PhD from Concordia University in 2012 and his Master's degree from Sharif University of Technology in 2006. His current research is on automated manufacturing of composites.

IMAGES COURTESY OF THE RESEARCHERS

With increasing use of composites in aircraft and automotive structures, automated composite manufacturing techniques have become essential and are attracting much interest from industry. In particular, the Automated Fiber Placement (AFP) process provides a new approach to the manufacturing of large-scale complex composite structures in comparison to traditional manufacturing techniques. AFP is a process in which composite tapes are laid onto a tool surface in a layer-by-layer manner and can be used in manufacturing both thermoset and thermoplastic composites.

Thermoplastic composites are of special interest due to their superior properties, especially with regards to fatigue and impact issues, infinite shelf life, weldability, toughness, chemical resistance etc. A unique advantage of thermoplastic composites is the possibility of in-situ consolidation that can be achieved using the AFP process alone thus avoiding secondary processes such as autoclave treatments which leads to significant manufacturing cost/energy savings. In addition, the possibility of recycling thermoplastic matrix would categorize thermoplastic composites in the field of green technologies.

Two main challenges that impede the wide application of thermoplastic composites are the quality of AFP in-situ consolidated laminates and the throughput of the process. Dr. Shadmehri's research focuses on quality and throughput improvement of AFP in-situ consolidation of thermoplastic composites via introducing innovative interventions and process simulation. Concordia Centre for Composites (CONCOM) is one of the few research centers in the academia with a AFP lab. The lab is equipped with a robotic-type AFP capable of processing both thermoplastic and thermoset composites.

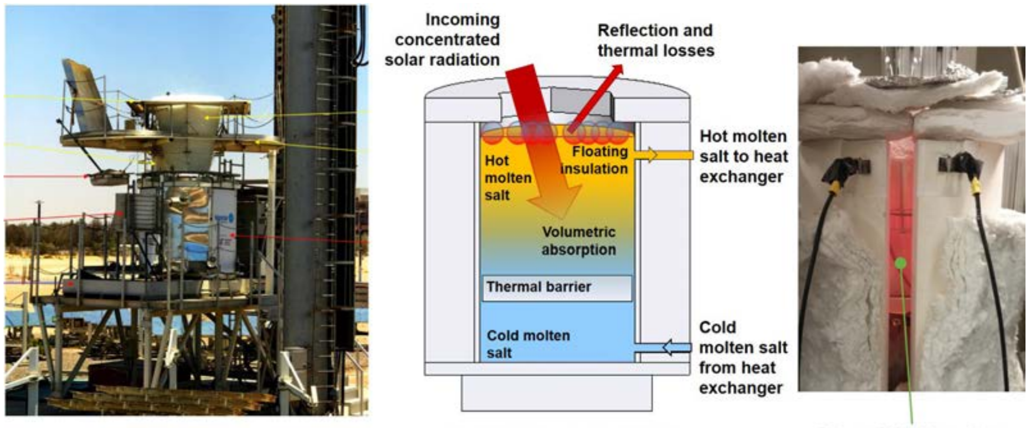
During AFP of thermoplastic composites, a moving heat source (e.g., hot gas torch, laser, or heat lamp) melts the thermoplastic polymer and fusion bonding takes place under the pressure applied by a roller and consolidation occurs in-situ. Due to the rapid heating and cooling of the material, many issues arise including thermal residual stress due to nonuniformity of temperature distribution and quality of bonding between layers. The most important process parameter in AFP in-situ consolidation that affects the quality is temperature. The microstructure of thermoplastic composites is affected by the thermal history during the AFP process. Material properties (density, specific heat capacity, and thermal conductivity), the crystallization behavior, and consolidation all depend on temperature. Thus, the importance of heat transfer analysis to predict temperature distribution accurately during the process is quite obvious.

Dr. Shadmehri's recent research is focused on developing 2D and 3D heat transfer models of AFP process capturing key elements of the process including moving heat source, transient nature of the process, and layer-by-layer material deposition. Furthermore, the effects of key process parameters during hot gas torch AFP including gas flow rate, temperature, torch configuration and layup speed on the convective heat transfer coefficient of AFP are investigated and a procedure for determination of AFP heat transfer characteristics is developed. This paves the way for other analyses and simulations like residual stress and deformation which the temperature distribution should be known a priori.

The long-term objective of Dr. Shadmehri's research is to bring AFP in-situ consolidation of thermoplastic process to the level that meets industry requirements in terms of quality and throughput.

McGill University
Dr. Mélanie Tétreault-Friend

Turning on the heat: Developing efficient high-temperature energy technologies using molten salts



CSPonD Demo Prototype

Illustration of a volumetrically absorbing, molten salt solar receiver.

Binary Chloride molten salt at 800 °C

FIG. 1: THE CSPonD IS A VOLUMETRICALLY ABSORBING MOLTEN SALT SOLAR RECEIVER WITH INTEGRAL THERMAL ENERGY STORAGE.

Dr. MÉLANIE TÉTREAULT-FRIEND, PhD

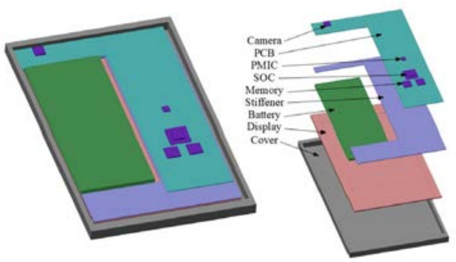
Dr. Tétreault-Friend has been an Assistant Professor in the Department of Mechanical Engineering at McGill University since 2018. She completed her Masters (2014) and PhD (2018) in Nuclear Science and Engineering at the Massachusetts Institute of Technology, specializing in thermal-hydraulics in power technology. She is an expert in boiling heat transfer and molten salt power technology. Her graduate research focused on heat transfer in advanced nuclear and solar-thermal energy technologies. She currently leads McGill's Thermal Energy Laboratory (TEL); a heat transfer laboratory specialized in solar thermal and advanced nuclear energy technologies. Her research webpage is: thermalenergy.lab.mcgill.ca.

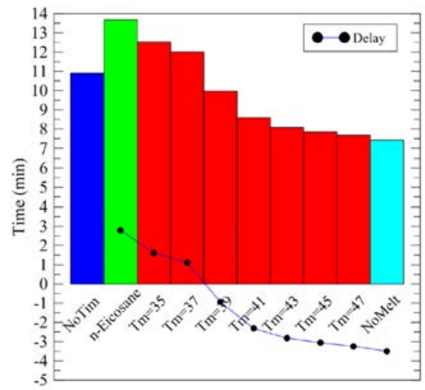
The mission of the Thermal Energy Lab (TEL) is to improve our understanding of heat transfer in molten salts and facilitate the design, licensing and certification of Canada's next generation of advanced low-carbon thermal energy technologies. In particular, molten salts have gained considerable interest in recent years as effective heat transfer fluids (HTF) and storage media in alternative low-carbon thermal energy technologies. They are obtained from melting readily available salt mixtures such as nitrates and chlorides. They are inexpensive, reach high temperatures at low pressures, have high heat capacities providing superior thermal energy storage, and have high nuclear fission burn-up. Molten salts are therefore excellent HTFs that can be used for a variety of thermal management applications and enable energy technologies with high power densities.

Salt mixtures have long been used in Canada and abroad as crop fertilizers and for metal heat treatment processes. Currently, they are being used in a variety of advanced energy applications such as Molten Salt Reactor (MSR) nuclear power plants, and Concentrated Solar Power (CSP) plants. Dr. Tétreault-Friend recently worked in the United Arab Emirates in collaboration with Khalifa University on the development and construction of an innovative 100 kW advanced solar receiver and thermal energy storage system called Concentrated Solar Power on Demand (CSPonD). The CSPonD consists of a volumetrically absorbing solar receiver with integral energy storage. The design uses concentrated solar power that directly irradiates a large open tank of semi-transparent molten salt at very high temperatures. The molten salt bath is used simultaneously for absorbing sunlight (receiver) and for energy storage such that power can be dispatched 24/7. It is designed to operate robustly and reliably with very low capital costs. Dr. Tétreault-Friend led the systems-level thermofluid analysis of the receiver system. She also developed a novel apparatus for measuring the absorption coefficient of high-temperature (>400 °C) molten salt mixtures subjected to various operating conditions. She developed start-up and operating procedures, and developed an innovative insulating floating cover that reduced heat losses by over 50 %. The breakthrough concept enables higher temperatures in liquid-based receivers, which in turn enables higher heat engine efficiencies. Her analyses also motivated the integration of auxiliary mixing mechanisms to improve the thermal performance.

The TEL is now working on developing new diagnostics and experimental techniques to advance our understanding of heat transfer in molten salts. A high-flux concentrating solar power facility is being designed to study cutting edge molten salt CSP technologies at high solar concentrations (>100 suns). In addition, the lab is developing advanced diagnostics for quantitative flow measurements in molten salts. The diagnostics techniques will be used to study radiation and convective interactions in volumetrically heated molten salts. This will allow making better thermal-hydraulics predictions to optimize the design of Canada's next generation of clean energy technology and further facilitate the licensing and commercialization of molten salt nuclear and solar energy technologies.

IMAGES COURTESY OF THE RESEARCHER



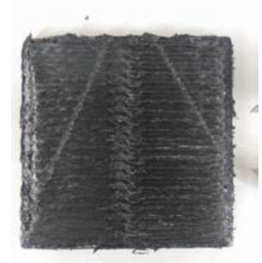


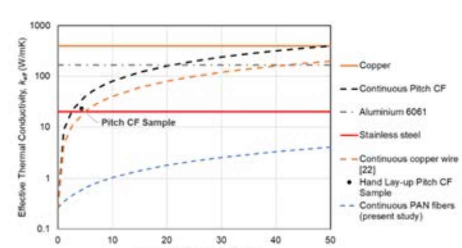
Phase Change Materials to Keep Smartphones Running Cool

The size of portable electronic devices like tablet computers and smartphones continues to decrease, while the demand for more processing power continues to increase. Thermal management of these compact devices remains a challenge because as they get smaller, their ability to passively shed the heat they generate during heavy processor usage is diminished. The embedded electrical components must be prevented from overheating, and the outer shell of the device must not become uncomfortably hot for the user. The Laboratory of Applied Multiphase Thermal Engineering, led by Prof. **Dominic Groulx** at Dalhousie University, has been exploring phase change materials (PCMs) as a possible solution to this problem. These substances absorb or release large amounts of 'latent' heat when they go through a change in their physical state, i.e. from solid to liquid and vice versa. As his team has demonstrated using both computational and experimental methods[1-3], PCMs can be effective at extending the duration of time during which processors can do heavy work, store that latent thermal energy, and then release it slowly later on when the phone is not in use. Dr. **Benjamin Sponagle**, who was a PhD student working on this project, created a finite element model of a tablet computer to parametrically analyze the performance of PCMs with different transition temperatures[1]. They determined that, based on their placement of the PCM, transition temperatures between 35-40°C were the most suitable, and this finding has guided subsequent experimental work using n-eicosane (PCM that melts at 37°C). Further development could lead to latent heat storage using PCMs being an important component in the thermal management of handheld devices. — *Technical Editor, Prof. Ryan Willing*

Thermally conductive 3D-printed continuous fiber polymer composites for high performance heat exchangers

Additive manufacture (AM) of heat exchangers is an attractive concept because it would allow for the manufacture of single-piece exchangers with complex geometries and structures with unprecedented surface area-to-volume ratios. Fused filament fabrication, the technique employed by most low-cost commercially available 3D printers, normally involves melting and extruding of polymers in a layer-by-layer fashion; however, these materials are poor heat conductors. Using composites of these polymers with more thermally-conductive filling materials such as metals, graphite and carbon fibers is an attractive solution, but the effective thermal conductivity is still quite limited. The Advanced Thermofluids and Heat Transfer Research Laboratory (TF-LAB) at York University, led by Professor **Roger Kempers**, has found a potential solution to this by using 3D-printed continuous fiber polymer composites. In their recently published study[4], the effects of the continuous PAN carbon-fiber direction and volume fraction on the effective thermal conductivity of 3D-printed composites were characterized experimentally and modeled analytically. They measured thermal conductivities of up to 2.97W/mK; an order of magnitude higher than polymers alone. Furthermore, they showed that much higher thermal conductivities would be obtained by using pitch carbon-fiber composites instead. Thus, future development of a process for 3D printing of pitch carbon-fiber composites could enable additive manufacture of composites with thermal conductivities comparable to aluminum, with anisotropic and tailorable conductivities. — *Technical Editor, Prof. Ryan Willing*





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emissions. Using CFD simulations, members of A-CFL focus on determining how wind-gusts affect the aerodynamics of trailer trucks and trains. The objective is to develop technologies that minimize the additional drag and side forces that currently require consistent course adjustment and maneuvering with negative impact on efficiency and stability. Moreover, Dr. Hemmati's group is currently studying the hydrodynamics of underwater fish swimming to enhance the design of aerial and underwater autonomous transportation systems.

Dr. Hemmati has recently started research on cardiovascular flow simulations in pediatric medicine. His aim is to develop better tools for cardiologists and surgeons to better diagnose cardiovascular disease, identify best medical treatments, and develop preventive tools for cardiovascular disease in children. He has succeeded in forming a large, diverse and international research team across three continents that consists of radiologists, computer scientists, engineers, cardiologists, neurologists and surgeons.

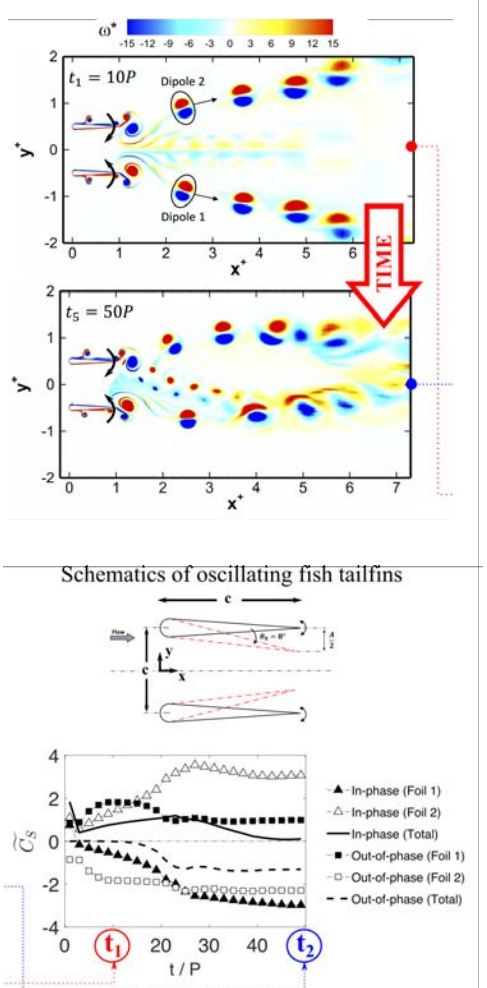

FIG. 3: THE HYDRODYNAMICS OF SWIMMING FISH: (A,B) THE WAKE OF FISH TAILFINS TRANSITIONS FROM SYMMETRIC TO ASYMMETRIC OVER TIME (P IS PERIOD OF FLAPPING); (C) THE EVOLUTION OF SIDE-FORCE (CS) IN TANDEM FOIL HYDRODYNAMICS ASSISTS IN LATERAL POSITIONING OF FISH ((PREPARED BY AHMET GUNGOR).

IN MEMORIAM

Dr. Samir Ziada (1949 - 2018)

It is with great regret that we announce the passing of Dr. Samir Ziada. Samir was a Professor and former Chair of Mechanical Engineering at McMaster University. Samir was born in 1949 in Cairo, Egypt, the youngest of four siblings. His early success in his engineering studies earned him a scholarship to continue his research in Canada and then the United States. After completing his PhD he was recruited to the Sulzer Technology Corporation in Switzerland where he enjoyed a fulfilling career and raised his children. In mid-life he accepted a position as a Professor of Mechanical Engineering at McMaster University which brought his family to Canada. Changing careers at nearly 50 years of age is consistent with the adventurous spirit that Samir embodied.

Samir was a brilliant scientist and engineer and made significant contributions to his academic field of flow induced vibrations and acoustics. His expertise was sought around the world, and he consulted on a wide variety of issues ranging from steam trains to hydro dams, solving many problems considered intractable. He was a Fellow of both the CSME and the ASME and was an Associate Editor for the *Journal of Fluids and Structures*.

As Department Chair from 2003 to 2008, Samir oversaw massive growth in the department with the hiring of ten faculty members. Samir mentored them in their careers and celebrated their successes even when his term as chair had been completed. He understood the importance of creating a collegial and welcoming environment and Samir and his wife Lynne hosted many departmental social events at their house.

Those who knew Samir will agree that he lived a full life. He loved classical music, good food and wine, sports, and travel. He was so proud of his family. Samir was an inspiration and role model on the importance of living life to the fullest. At the time of his cancer diagnosis, he felt it was too soon, but also let his family know he had enjoyed all life had to offer, never putting off what he most wanted to do. His family is grateful that he lived a full life, enjoyed great success and knew he was loved. – *Dr. M. Lightstone*

References: Novel Heat Transfer Related Research Ontario Tech University ***(Feature page 14)***

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CSME STUDENT AFFAIRS & YOUNG PROFESSIONALS
REPORT

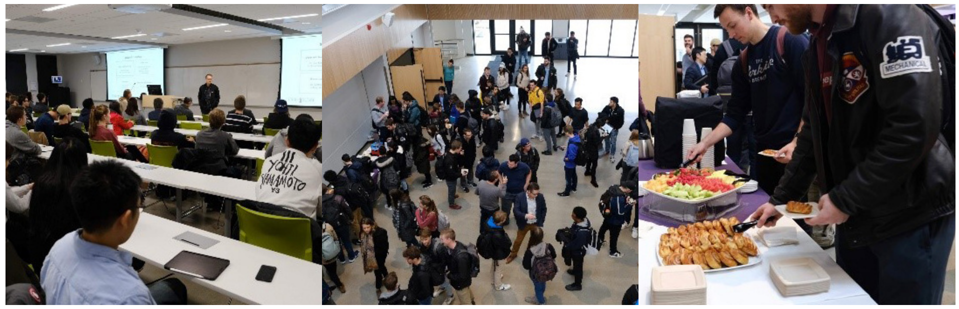
THE CSME STUDENT AFFAIRS & YOUNG Professionals Committee facilitates the CSME Student Chapters and new Chapters to organize events, networking and outreach activities. During the past year, several chapters ran exciting events; although, several events were planned and were not able to run due to the ongoing COVID-19 pandemic, the chapters are keeping their enthusiasm to run these events in the future when it is safe to do so again! For example, a drone racing competition organized by the **CSME uOttawa Student Chapter**; a women in engineering panel with five keynote speakers organized by the **CSME Ryerson Student Chapter**, a tour of the Formet Industries (a division of Magna International) plant by the **CSME Western Student Chapter** and several other events were postponed. We are looking forward to when chapters will be able to host these exciting events!

The CSME uOttawa chapter hosted a Meet & Greet event on November 30, 2019 to introduce the CSME to students at the University of Ottawa. The CSME Western chapter hosted a Student & Faculty Mixer on November 30, 2019.

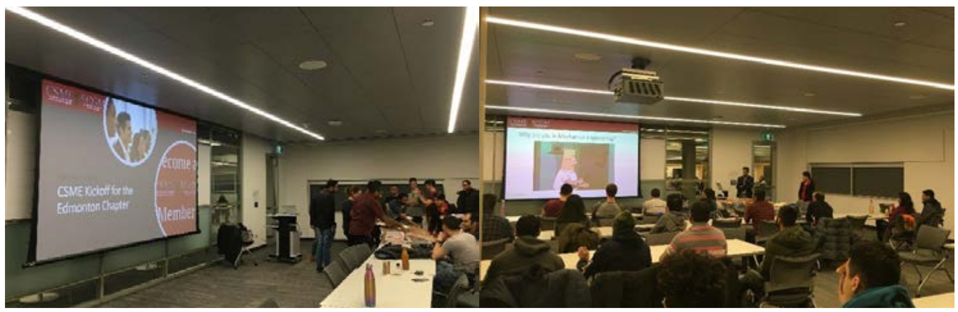
CSME uOTTAWA STUDENT CHAPTER: MEET & GREET EVENT IN NOVEMBER 2019

The Young Professional chapter in Edmonton was formed this past year, led by **J. Samuel Parcon**. They held a kick-off event in December 2019, which was well attended by thirty professionals from various industries in the field of mechanical engineering. The committee also organized two tours of industry facilities including the City of Edmonton's Waste Management Centre and the Lafarge Canada precast plant which were both held in February 2020.

PHOTOS COURTESY OF THE CHAPTERS



CSME WESTERN STUDENT CHAPTER: STUDENT & FACULTY MIXER EVENT IN NOVEMBER 2019



EDMONTON YOUNG PROFESSIONALS CHAPTER: DECEMBER 2019 KICK-OFF EVENT

In its inaugural year, the **CSME Chittagong University of Engineering Technology (CUET)** Student chapter led by **Abu Raihan Ibna Ali** organized several events, including a tour at the Hydrogen Energy Laboratory, Chattogram, which is a laboratory of the Bangladesh Council of Scientific and Industrial Research (BCSIR); a tour of the Chittagong Power Station; and two online presentations from Dr. **Ashraf Ali** from Boeing and Dr. **Ben Todd**, CEO of Arcola Energy); and visited 420 MW Chittagong Power Station (CPS). In the tour of the Chittagong Power Station, students were accompanied by Dr. **Bably Das**, faculty member of the Department of Mechanical Engineering, CUET, Bangladesh. During the visit, students learned about the various sections of the power plant from the power station engineers, including the boiler, turbine, cooling tower, generator, etc. Students also toured the transmission control room, load management, monitoring room, generating substations and distribution switch terminals. The tour was complemented with a lecture session on the overall working procedure of this crucial power plant which provided insight into the operations and maintenance. CSME CUET Student Chapter (www.csme-cuet.com) students enjoyed learning about the practical engineering aspects from visiting the operational thermal powerplant.

CSME CUET STUDENT CHAPTER: STUDENTS AT THE 420MW CHITTAGONG THERMAL POWER STATION IN MARCH 2020

Interested in leading and founding a CSME Student or Young Professionals Chapter? Contact us: marina.freire-gormaly@lassonde.yorku.ca or faizul.mohee@utoronto.ca

Student Gold Medal Awards

Every year, CSME Gold Medals are presented to top-performing students at participating Universities. The medals are awarded by CSME Sustaining Members (ME departments) to students for Outstanding Academic Achievement in Mechanical Engineering. For 2020, the CSME has been advised of, and wishes to congratulate, the following Gold Medal recipients for their outstanding achievements.

Chaque année, dans les universités participantes, les membres souteneurs décernent les médailles d'or de la SCGM aux étudiants pour réussite académique exceptionnelle en génie mécanique. Pour l'année 2020, la SCGM a été avisé et félicite les personnes suivantes pour s'être gagnées une médaille d'or de la SCGM.

csme-scgm.ca/student_awards

Arashdeep Dhillon
British Columbia Institute of Technology

Christopher Beers
Carleton University

Alec Freeman
Dalhousie University

Corentin Boucher
École de technologie supérieure

Danyk Levesque
Laurentian University

Ran Huo
McGill University

(Ms) **Stacey Mark**
McMaster University

Laura Murphy
Memorial University

William James Collings
Ontario Tech University

Christophe Absi
Polytechnique de Montréal

Patrick Shorey
Queen's University

Liam Kerr
Ryerson University

Curtis Stewart
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Eleni Sabourin
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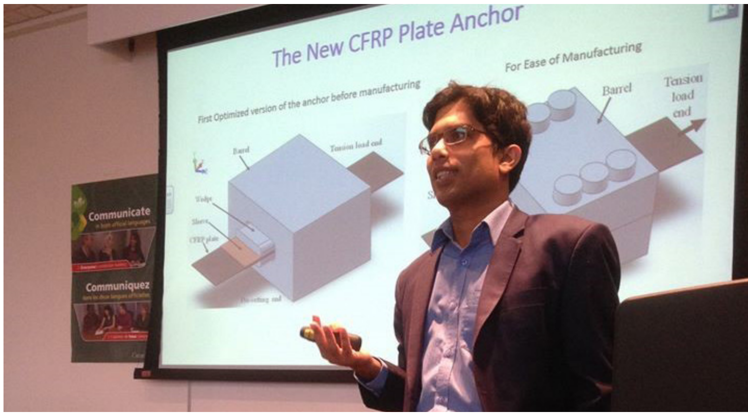
Madeline Martel
University of Saskatchewan

Marie Floryan
University of Toronto

Amandine Drew
University of Western Ontario

Daniel Colvin
York University



CARLETON UNIVERSITY: DR. FAIZUL MOHEE AND DR. MARINA FREIRE-GORMALY PRESENTED TO GRADUATE MECHANICAL ENGINEERING STUDENTS AT CARLETON UNIVERSITY IN FEBRUARY 2020

Dr. **Faizul Mohee** and Dr. **Marina Freire-Gormaly** presented the CSME student program and their research to graduate students in mechancial engineering at Carleton University in February 2020. Dr. Mohee discussed his research on fibre-reinforced polymer (FRP) composite materials, small modular reactors in the nuclear industry and the impacts of climate change on engineering design. Dr. Freire-Gormaly shared the design of energy and water systems and various projects underway with her research team at York University. The students were very engaged and there was a lively discussion during the talks.

Please join as a CSME member, it is FREE for students (csme-scgm.ca/application). The Engineering Careers site (www.engineeringcareers.ca) also provides an opportunity to plan for your career. We are also looking forward to a CSME internship program for students to participate in industry.

Thank you to all the student chapter executives, volunteers and faculty mentors for your hard work! If you're interested in leading and founding a CSME Student Chapter at your campus, let us know. Contact us at marina.freire-gormaly@lassonde.yorku.ca or faizul.mohee@utoronto.ca or the CSME directly and we will walk you through the process. We are also looking to expand the CSME Student Affairs and Young Professionals Committee. If you are interested in helping lead activities locally or at the national level, please reach out.

Do you have a great idea, story or proposal to improve the CSME student programming? Feel free to share your ideas with us!

DR. MARINA FREIRE-GORMALY, PhD, EIT, LEED GA, Chair of CSME Student Affairs & Young Professionals

Marina is an Assistant Professor at York University in the Department of Mechanical Engineering. She completed her PhD at the University of Toronto in the Department of Mechanical & Industrial Engineering. Marina's research team is investigating how COVID-19 transmits in air, and how to make energy and water systems more reliable and sustainable. Her research and teaching spans energy systems, nuclear, computational modelling and sustainability.

DR. FAIZUL M. MOHEE, PhD, P.Eng., PMP Vice-Chair of CSME Student Affairs & Young Professionals

Faizul is the Director of Research at TMBNExtrados Inc. in Toronto. Faizul is an adjunct professor in Engineering at the University of Toronto. He completed his PhD at the University of Waterloo on mechanical anchors for composite materials. He also did a master's at U of T. He has taught a Machine Learning, Artificial Intelligence and Big Data for Manufacturing course at York University. He also taught the Materials Science course at U of T's Department of Mechanical & Industrial Engineering. He previously worked at Hatch, WSP and projects for OPG, Bruce Power, Terrestrial Energy, Baffinland, Stornoway, SaskPower and Emera. Faizul works in research and development for the energy, mining and nuclear industries. Faizul is currently is conducting research on COVID-19 transmits in air and HVAC systems. Faizul is passionate about research, teaching and student engagement to build smart and sustainable infrastructure that is resilient and adaptive to climate change.

FACULTY OF ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

www.unb.ca/hr/careers

COMPETITION: #19-45

DEPARTMENT OF MECHANICAL ENGINEERING
Assistant Professor in Experimental Fluid Mechanics

The University of New Brunswick, Department of Mechanical Engineering, invites applicants for a tenure stream appointment at the Assistant Professor level with specialization in Experimental Fluid Mechanics. Duties in the Department will include teaching undergraduate courses in the core Mechanical Engineering curriculum, offering courses in the area of the appointee's research specialty at the senior undergraduate and/or graduate level, and conducting research. The Department currently has approximately 350 undergraduate students and 60 full-time graduate students. In addition to a standard Mechanical Engineering program, options in Mechatronics and Biomedical Engineering are also offered. Further information about the Department can be found at www.me.unb.ca.

The appointee must have completed an earned doctorate in Mechanical Engineering or similar area. The appointee shall be eligible and willing to become a registered Professional Engineer in the Province of New Brunswick.

Applications, including a curriculum vitae, a teaching dossier (if available), a research plan, and the names of three academic references, should be sent to

Chair of the Search Committee
Department of Mechanical Engineering
University of New Brunswick
P.O. Box 4400
Fredericton, NB E3B 5A3

E-mail: meceng01@unb.ca
Fax: (506)453-5025

Review of applications will begin immediately and continue until the position is filled. This position is subject to final budgetary approval.

Short-listed candidates will be required to provide satisfactory proof of credentials including appropriately certified translations of credentials into English, as applicable.

The University of New Brunswick is committed to employment equity and fostering diversity within our community and developing an inclusive workplace that reflects the richness of the broader community that we serve. The University welcomes and encourages applications from all qualified individuals who will help us achieve our goals, including women, visible minorities, Aboriginal persons, persons with disabilities, persons of any sexual orientation, gender identity or gender expression. Preference will be given to Canadian citizens and permanent residents of Canada.

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