CSME BULLETIN SCGM

THE CANADIAN SOCIETY FOR MECHANICAL ENGINEERING
LA SOCIÉTÉ CANADIENNE DE GÉNIE MÉCANIQUE

Canadian Engineering Teams Dominate Eco-Marathon Americas 2014

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President's Message/Message de la Présidente

Christine Wu, Ph.D., P.Eng., FCSME

I have had a privilege to serve as CSME's President since June 2012 and my term ended in June 2014. I will continue to support CSME as its past President and the Chair of Awards and Ceremony Committee for another two-year term. During the last two years, CSME has continued to develop its memberships and enhance its activities to better serve its members and the community. In 2013, the memberships of CSME have grown by 30% and the 2014 memberships appear to be on track to meet or exceed 2013. CSME has established student chapters in 10 Canadian universities with mechanical engineering departments and programs. We allocate $500 per year to each student chapter to support their professional development activities. Since 2012, we have sponsored 12 such student activities, from industrial tours to workshops on job negotiation and networking. CSME has continued to communicate the needs of the mechanical engineering profession with NSERC and EIC, and has facilitated networking among its members to showcase their strength and contributions through various technical and standing committees, communication tools such as the CSME bulletin and transactions and regional chapters. CSME has also continued to support and sponsor several international conferences and promote mechanical engineering in these events. CSME will work with NRC (National Research Council Canada) and IUTAM (International Union Theoretical and Applied Mechanics (IUTAM)) to organize the 24th International Congress of Theoretical and Applied Mechanics in Montreal, QC, from August 21 to 26, 2016.

The biannual CSME International Congress 2014 was held at the Department of Mechanical & Industrial Engineering, University of Toronto from June 1-4, 2014. It is the flagship conference of CSME, and it is an un-precedent successful event. For the very first time, the CFD Society of Canada's 22nd Annual Conference was held as a concurrent conference at the CSME International Congress. The three-day program featured six distinguished keynote speakers, an extensive technical program with parallel sessions, symposiums, special sessions, and workshops. Nearly 400 papers have been presented demonstrating the scope of today's mechanical engineering research. Other technical activities also include NSERC Information Session and Workshop, Sponsor presentations, CSME Student Design Competition, CSME Student Paper Competition and technical tours. I would like to take this opportunity to thank Dr. Jean Zu, the CSME Conference Chair, Dr. Markus Bussmann, the 22nd Annual CFD Conference Chair and their organizing committees for organizing such a successful conference.

I would like to congratulate Cristina Amon (Dean of the Faculty of Applied Sciences and Engineering, University of Toronto) for receiving the Robert W. Angus Medal, Tobin Filleter (Assistant Professor, Department of Mechanical and Industrial Engineering, University of Toronto) for receiving I.W. Smith Award, and Paul Zsombor Murray (Professor, Department of Mechanical Engineering, McGill University) for receiving C.N. Downing Award. Congratulations also go to Nasser Ashgriz (Professor, Department of Mechanical and Industrial Engineering, University of Toronto) and Sushanta Mitra (Professor, Department of Mechanical Engineering, University of Alberta), who are the 2014 recipients of EIC Fellow (nominated by CSME).

As Dr. Xiaodong Wang and Dr. Kamran Siddiqui have completed their editorships for the CSME Bulletin, on behalf of CSME, I would like to express my sincere appreciation to both of them for their commitment and contributions to publishing the Bulletin for the past several years. The Bulletin is a vital tool for CSME to communicate with its members, and to showcase our members' achievements and contributions. Dr. David Sinton, from University of Toronto, has agreed to be the new editor of the bulletin. We look forward to working with Dr. Sinton on the CSME Bulletin.

Last, but not least, a heart-felt "thank you" to Mr. John Plant, CSME Executive Director, and Ms. Louise McNamara, CSME Administrative Assistant, for their effort and dedication in managing the office and dealing with CSME's day-to-day operations.

This is a great time to get involved in CSME. I wish you and CSME the very best.

Sincerely yours,

Christine Q. Wu, Ph.D., P.Eng., FCSME
Professor and NSERC Industrial Research Chair
Department of Mechanical and Manufacturing Engineering
University of Manitoba

J'ai eu le privilège d'être présidente de CSME de juin 2012 à juin 2014. Je vais continuer d'appuyer CSME comme ancienne présidente ainsi que continuer comme présidente du Comité des prix et de cérémonie pour un autre mandat de deux ans. Au cours des deux dernières années, CSME a continué à développer ses adhésions et de renforcer ses activités afin de mieux servir ses membres et la communauté. En 2013, les adhésions de CSME ont augmenté de 30% et en 2014 l'adhésion semble être sur la bonne voie pour atteindre ou dépasser celles de 2013. CSME a établi des chapitres d'étudiants dans dix universités canadiennes avec des ministères et des programmes en génie mécanique. Nous allouons 500 $ par année pour chaque chapitre d'étudiants afin de soutenir leurs activités de perfectionnement professionnel. Depuis 2012, nous avons parrainé douze activités pour les élèves, tel que des visites industrielles ainsi que des ateliers pour l'emploi sur la négociation et le réseautage. CSME continue à communiquer les besoins de la profession d'ingénieur mécanique avec NSERC et EIC. CSME facilite le réseautage entre ses membres pour mettre en valeur leurs forces et leurs contributions par le biais de sections regionales, de divers comités techniques et permanents ainsi que des outils de communication tel que le bulletin et les transactions CSME. CSME continue également à soutenir et parrainer plusieurs conférences internationales et de promouvoir l'ingénierie mécanique dans ces événements. CSME va travailler avec le CNRC (Conseil National de Recherches Canada) et IUTAM (Union Internationale de Mécanique Théorique et Appliquée) pour organiser le 24e Congrès International de Mécanique Théorique et Appliquée à Montréal, QC qui aura lieu du 21 au 26 août, 2016.

Le Congrès Semestriel International 2014 du CSME a eu lieu du 1er au 4 juin à l'Université de Toronto (Département de génie mécanique et de génie industriel). C'est la conférence phare du CSME et il s'agit d'un événement couronné de succès sans précédent. Pour la première fois, la 22e conférence de la société CFD du Canada a eu lieu comme conférence simultanée au Congrès International CSME. Le programme de trois jours comprenait six conférenciers distingués, un programme technique détaillé de sessions spéciales et parallèles, des colloques et des ateliers. Près de 400 documents ont été présentés montrant l'étendue aujourd'hui de la recherche en génie mécanique. D'autres activités techniques comprises étaient la session d'information et l'atelier NSERC, des présentations de parrains, le concours d'étudiants CSME de design, le concours d'étudiants CSME de dissertation ainsi que des visites techniques. Je voudrais profiter de cette occasion pour remercier le Docteur Jean Zu, président de la conférence CSME, le Docteur Markus Bussmann, président de la 22e conférence annuelle de CFD ainsi que leurs comités. Grâce à eux, la conférence fut une réussite.

Je tiens à féliciter Cristina Amon (doyenne de la Faculté des Sciences Appliquées et de Génie, Université de Toronto) d'avoir reçu la Médaille Robert W. Angus, Tobin Filleter (professeur adjoint, Département de Génie Mécanique et de Génie Industriel, Université de Toronto) d'avoir recu le prix I.W. Smith et Paul Zsombor Murray (professeur, Département de Génie Mécanique, Université McGill) d'avoir recu le prix C.N. Downing. Félicitations aussi à Nasser Ashgriz (professeur, Département de Génie Mécanique et Industriel, Université de Toronto) et Sushanta Mitra (professeure, Département de Génie Mécanique, Université de l'Alberta) qui sont les bénéficiaires de l'EIC Fellow, 2014 (désignés par CSME).

Au nom du CSME, je tiens à exprimer ma reconnaissance sincère au Docteur Xiaodong Wang et au Docteur Kamran Siddi qui ont terminé leurs directions éditoriales pour le Bulletin CSME. Je vous remercie pour votre engagement et votre contribution à la publication du Bulletin. Le Bulletin CSME est un outil essentiel qui sert à communiquer avec les members et de mettre en valeur leurs réalisations et leurs contributions. Le Docteur David Sinton, de l'Université de Toronto, a accepté d'être le nouveau rédacteur en chef du Bulletin et nous attendons avec impatience travailler avec lui.

Pour finir, je tiens à remercier sincèrement Monsieur John Plant, Directeur exécutif du CSME et Mme Louise McNamara, Adjointe administrative, pour leur dévouement à la gestion du bureau et aux operations jour-à-jour du CSME.

Je vous encourage de vous engager dans CSME.

Je vous prie d'agréer l'expression de mes sentiments les meilleurs,

Christine Q. Wu, Ph.D., P.Eng., FCSME
Professor and NSERC Research Chair
Department of Mechanical Engineering
University of Manitoba

BECOME A CSME MEMBER

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MEMBERSHIP FEES

Member $140
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Mechanical Engineers Connect at CSME International Congress

by Nina Haikara, Communications & Special Projects Coordinator, Department of Mechanical & Industrial Engineering, University of Toronto

Canadian Society for Mechanical Engineering (CSME) and the CFD Society of Canada hold concurrent conference at U of T Engineering

From aerospace and biomedical engineering, to robotics and vehicle dynamics, mechanical engineers contribute to many industries that touch our lives every day.

From June 1 – 4, U of T Engineering welcomed over 400 mechanical engineering students and academics for the biennial Canadian Society for Mechanical Engineering (CSME) International Congress. With delegates joining from 14 different countries – including as far as China, Nigeria, the Netherlands and Iran – the four-day conference saw presentations of more than 350 research papers from across the field.

The CSME International Congress facilitates networking and the dissemination of research and new technologies amongst universities, industries, government agencies and R&D laboratories.

This year, the CFD Society of Canada – a forum for researchers in the area of computational fluid dynamics – also held their 22nd annual conference in conjunction with CSME.

"It was a unique opportunity to bring together CFDSC and CSME," said Markus Bussmann, vice dean, graduate studies, and chair of this year's CFDSC conference. "CFD encompasses a broad spectrum of application areas, and many of the papers presented as part of CSME, are of equal interest to CFDSC members. It was a successful experiment, bringing the two societies together for one joint conference."

U of T Engineering Dean Cristina Amon was one of six keynote speakers at the event. She addressed attendees on the topic of engineering education, sharing the importance of diversity and system-thinking, as well as instilling professional transferable skills including global outlook, leadership and entrepreneurship. Other keynote speakers included Elliot L. Chaikof, Harvard University, and Grétar Tryggvason, University of Notre Dame.

Dean Amon and Professor Jean Zu, chair of mechanical engineering at U of T, also took part in a special panel discussion during symposium session on women in engineering. Organized by Christine Wu, University of Manitoba professor and president of CSME, the special session included a keynote address by Catherine Mavriplis, a University of Ottawa professor and NSERC/ Pratt & Whitney Canada Chair for Women in Science and Engineering. Professor Mavriplis shared new initiatives that are underway in both academia and industry that demonstrate positive approaches to promoting women's advancement to leadership in engineering.

During the conference banquet, which recognized recently named CSME fellows and award winners, the CFD Society of Canada honoured Professor Dominique Pelletier, École Polytechnique de Montréal, with a Lifetime Achievement Award. He was recognized as an individual who has made outstanding time-enduring contributions to computational fluid dynamics in Canada, and he is only the third recipient of honour in the 22-year history of the society.

Additional events included a reception at Hart House, a research poster showcase by MIE graduate students, mechanical engineering lab tours, an NSERC information session and special musical performances by the U of T Engineering Iron Strings quartet and Skule Jazz combo.

"We are very proud to have hosted a productive and successful CSME and CFDSC," said Professor Jean Zu, chair of this this year's Congress. "By bringing both national and international researchers together, we understand more deeply the importance of learning from the expertise of our engineering colleagues."

The next CSME International Congress will be hosted by the School of Engineering at the University of British Columbia, Okanagan in 2016.

Canadian Engineering Teams Dominate Eco-Marathon Americas 2014

Prashanth Murali[1] and Mengqi Wang[2]
[1] Department of Mechanical and Industrial Engineering, University of Toronto, Toronto, ON, Canada
[2] Department of Electrical and Computer Engineering, University of Toronto, ON, Canada

The Shell Eco-Marathon is a globally run, annual competition which challenges university and high school engineering teams around the world to design and fabricate custom vehicles with the ultimate goal of achieving top energy efficiency performance.

The competition is divided into 2 categories based on the type of vehicle, namely the Prototype Class and the Urban Concept Class. Within each class, student teams are encouraged to design with an array of energy types in mind, including gasoline, hydrogen fuel cell, battery electric, diesel, and solar. The top three performing vehicles of each class and fuel type are awarded with a trophy and prize money.

Now in its 73rd year, the 2014 Eco-Marathon Americas event was held in Houston, Texas from April 24th through the 27th, and was host to more than 1000 students participating in 121 teams from countries across North, Central and South America. Of special note were the Canadian teams who, though few in number, swept up awards both on-track and off-track alike.

The most popular category in the competition, the gasoline-powered Prototype Class, pitted defending champions, Université Laval's team Alérion, against a surprise contender from the University of Toronto, team Supermileage.

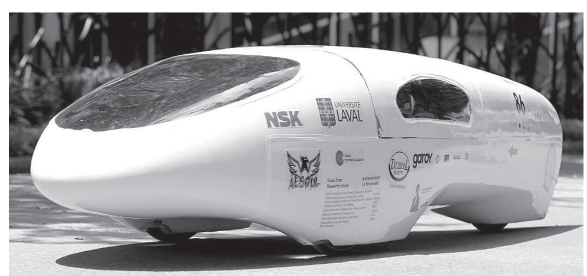
Traditionally, the prototype category provides the greatest potential to participants in terms of attainable mileage. Laval's streamlined, all white vehicle was powered by a modified Briggs & Stratton engine, and holds the current Americas record for gasoline mileage at an astounding 1525km/L (3587mpg). With that level of efficiency, the Alérion car could drive from Vancouver to Saskatoon on a single liter of fuel.

Though only participating for the second year, the University of Toronto's Supermileage team proved to be a strong competitor to Laval. Their glossy black, carbon fiber finished car is the only vehicle to date to run a fully custom designed, in-house built engine at the Americas competition.

These two teams kept the race close throughout the weekend, trading first and second place every round. Ultimately, team Alérion from Laval emerged victorious, with an impressive mileage of 1201 km/L (2824 mpg), adding to their winning streak of top place in the last 5 of 6 Eco-Marathon events. In second place, Toronto's Supermileage team achieved a respectable 1153 km/L (2713 mpg). Not to be overshadowed, however, team Supermileage augmented their second place prize with two off-track awards, namely the Technical Innovation award, for the successful performance of their fully custom built engine, and the Pennzoil Tribology Award, for their specific application of lubrication engineering principles to improve engine performance. In the same gasoline Prototype category, Dalhousie University obtained 4th place with a final mileage of 931 km/L (2190 mpg), followed by École de Technologie Supérieure in 9th place, Université de Moncton in 22nd, and Queen's University in 28th place.

Canadian teams also held a strong finish in the Urban Concept Class. Design and safety rules in this category are notably stricter than those in Protoype, with the ultimate intention of building vehicles which can be street legalised. Regardless of the tougher restrictions, however, Canadian teams dominated the podium, with Université de Sherbrooke claiming 1st place in the battery electric category, University of Alberta taking home 1st place in the hydrogen fuel cell category, and the University of British Columbia clinching 3rd place in the gasoline category.

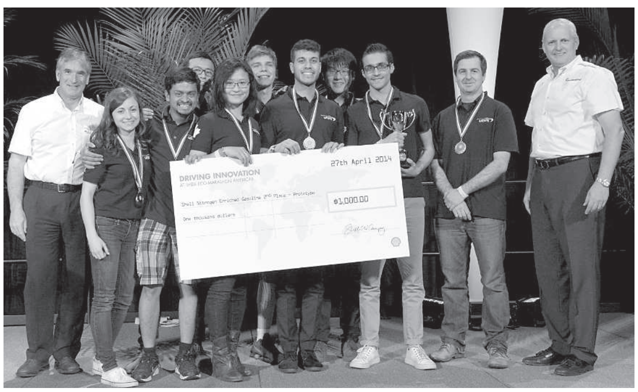
The success of the Canadian teams in this year's Shell Eco-Marathon Americas event will be sure to draw more participation from engineering teams from universities across Canada in Eco-Marathon Americas 2015. Next year's competition will be hosted a little closer to home in Detroit, Michigan. Undoubtedly attention will be on the promise for further innovation and improved performance from Canadian teams. The friendly rivalry between Université Laval and the University of Toronto will, in itself, be a sight to see in the upcoming event.



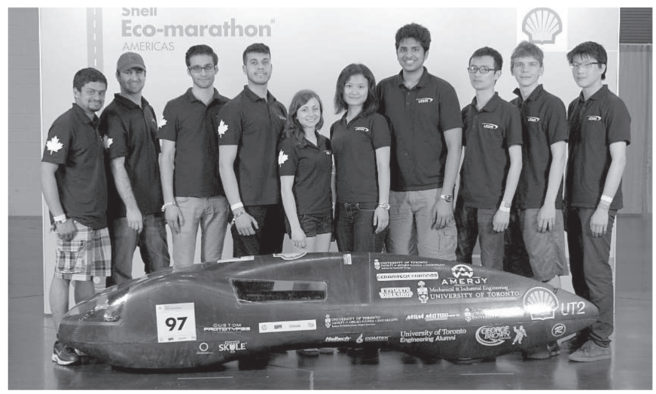
Université Laval team Alérion, gasoline Prototype vehicle, Eco-Marathon 2014. (courtesy of Shell Eco-Marathon)

University of Toronto team Supermileage, gasoline Prototype vehicle “UT2”, Eco-Marathon 2014. (courtesy of Shell Eco-Marathon)

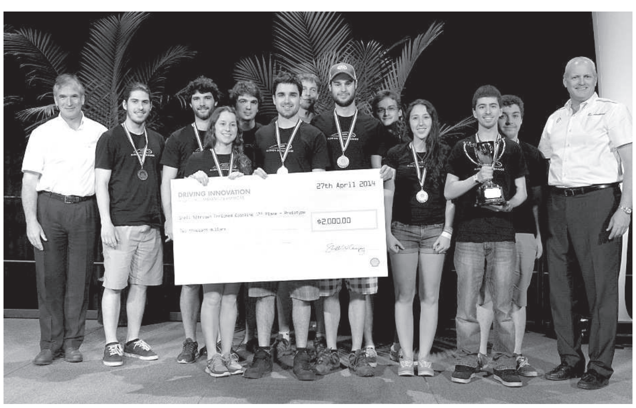
University of Alberta team EcoCar, hydrogen fuel cell Urban Concept vehicle, Eco-Marathon 2014 (courtesy of Shell Eco-Marathon)



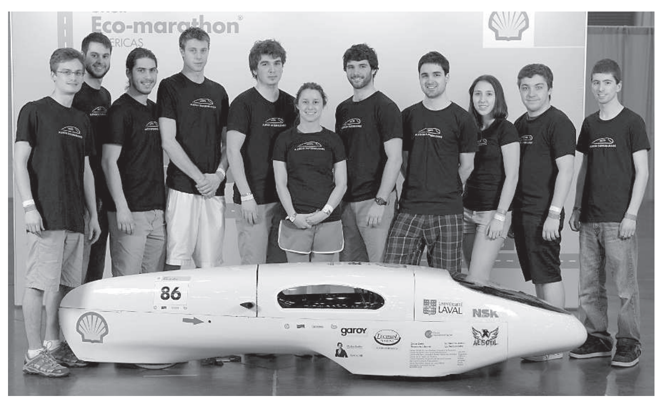
University of Toronto team Supermileage on stage for the second place prize, Eco-Marathon 2014. (courtesy of Shell Eco-Marathon)



University of Toronto Supermileage team photo with gasoline Prototype vehicle “UT2”, Eco-Marathon 2014. (courtesy of Shell Eco-Marathon)



Université Laval team Alérion on stage for the first place prize, Eco-Marathon 2014. (courtesy of Shell Eco-Marathon)



Université Laval Alérion team photo with gasoline Prototype vehicle, Eco-Marathon 2014. (courtesy of Shell Eco-Marathon)

Dr. Ruxandra Mihaela Botez, Canada Research Chair (Tier 1) in Aircraft Modelling and Simulation Technologies
École de Technologie Supérieure
Montréal, Québec, Canada

Professor Ruxandra Botez received her Bachelor's degree in Aircraft Design Engineering from the Faculty of Aircraft Design in Bucharest, Romania in 1984. Ruxandra became an Aircraft Design Engineer and her graduation project concerned gust load studies on the IAR-99 military aircraft. She worked from 1984-1987 as an Engineer at the aeronautical company ICA-Brasov in Romania. Ruxandra received her Master's degree in Applied Sciences, on Dynamic Stall research for helicopters from Ecole Polytechnique in Montreal in 1989. This research was of interest to Bell Helicopter Textron. Ruxandra obtained her PhD degree from McGill University in 1994 in the area of Fluid-Structure Interactions and Nonlinear Dynamics. Next, she worked as a Postdoctoral Fellow in helicopter control at Auburn University in the USA until 1995, and then she became the AeroServoElasticity task leader in the Active Control Technology project at Bombardier Aerospace.

She started working at the ETS as an Associate Professor in 1998, and became Full Professor in 2003. She founded the Research Laboratory in Active Controls, Avionics and AeroServoElasticity LARCASE in 2003, and has continued to be its director. The LARCASE is one of the rare academic aeronautical laboratories equipped with three major aerospace infrastructures, all acquired by Dr Ruxandra Botez. These are: the Research Aircraft Flight Simulator (RAFS) from CAE Inc. for the Cessna Citation X, the Price-Païdoussis Subsonic Blow-Down Wind Tunnel, and the Unmanned Aerial System UAS-S4 from Hydra Technologies in Mexico.

Dr. Botez's leadership can be seen in the success of research projects jointly conducted with Aerospace companies, research institutes and universities, such as NASA DFRC (USA), Bombardier Aerospace, Thales, Bell Helicopter Textron, CAE Inc., CMC Electronics-Esterline, Presagis, US Naval Research Laboratories, DLR (Germany), the US Air Force Academy and 50 other NATO participants, Hydra Technology (Mexico), Alenia, CIRA and the University of Naples (Italy), and INCAS and the University of Craiova (Romania). Since 2006, students working on research projects under Dr Botez' supervision have received 14 awards at various competitions. In addition, four Master's theses, one Bachelor report and one PhD thesis were recognized as excellent. Three of those students' presentations earned *excellent* at IEEE conferences.

During two CRIAQ competitions, her team received the *Second Award* for the CRIAQ MDO 505 project in April 2014, and the *Third Award* for the CRIAQ 7.1 completed project in March 2012. Dr Botez and her team received two other awards in 2012: the *Presagis award* for the *Best Simulation Model,* which was completed for the Hawker 800 XP business aircraft, and the *RTO Scientific Achievement Award*, the prestigious award offered to the NATO research team AVT-161. Dr Botez and her team worked with the AVT-161 team on the military X-31 aircraft. At the *Greener Aviation: Clean Sky breakthroughs and worldwide status conference* during 12-14th of March 2014 in Brussels, Belgium, Professor Botez name was included in the *Short List* for the Award selection at this conference. In 2007, Dr Botez received the *Certificat of Excellence to CRIAQ Pioneers* from CRIAQ and the *ETS Award of Excellence* for her exceptional researcher qualities, industrial achievements, and the graduation of around 150 Bachelor, Master's and PhD students. Ruxandra was also a finalist in the *2006 Women of Distinction Gala in the*

Education Category organized by the YWCA Foundation. Ruxandra is author and co-author of 77 referred journal papers, 164 referred conference papers and 4 invited book chapters. The activities of Dr Botez have been mentioned by the media in more than 60 papers and interviews published in different languages: French, English, Romanian, Italian and Spanish.

Q: What's the best part of your job?

A: The best part of my job is working on and completing aerospace projects in collaboration with aerospace companies in Montreal, where most of the Canadian aerospace industry is located, as well as on an international scale with US, European and Mexican partners. Students who have had the opportunity to work on these projects at the LARCASE can find challenging careers in aircraft design after their graduation. Women are always encouraged to work in our aeronautical laboratory.

Q: What's the favorite part of your career?

A: One of my favorite parts of my present career is the pilot training on the Unmanned System UAS-S4 that was bought with research funds from Hydra Technologies in Mexico. This training includes flying three different UAVs: a 25 kg radio-controlled Corrostick, the 30 kg radio-controlled Ground Control Station (GCS) Guerrero and a 75 kg UAS-S4 GCS. My passion for Aircraft Design Engineering is very close to my passion for flight training.

Q: Who (other than family members) do you admire most?

A: Think that people who have a passion for their work should be admired.

Q: What's one piece of advice you would give to Women in Engineering?

A: I think that it is extremely important to have a passion to work in engineering. I also believe that we should remain true to our femininity in terms of dress and behaviour, and be proud of our achievements and the fact that we are a minority in Mechanical Engineering. By our presence and success in this field, we are all contributing to the advancement of younger generations. Photos show Ruxandra with the LARCASE equipments.

The three photos show Ruxandra in front of the Aircraft Research Flight Simulator from CAE Inc., the Unmanned Aerial System UAS-S4 from Hydra technologies in Mexico and the Wind Tunnel Blow Down Subsonic Price-Païdoussis.

LARCASE web site: **www.larcase.etsmtl.ca;**
Research Gate web site: **https://www.researchgate.net/profile/Ruxandra_Botez?ev=hdr_xprf;**
Canada Research Chair in Aircraft Modeling and Simulation Technologies; **http://www.chairs-chaires.gc.ca/chairholders-titulaires/profile-eng.aspx?profileId=2744**

Excellent Women Mechanical Engineers

Marilyn Lightstone

Marilyn Lightstone is currently a Professor and Chair of Mechanical Engineering at McMaster University. She is a Professional Engineer registered in Ontario. Marilyn is the first female Chair in the history of the Faculty of Engineering at McMaster University. She was previously Associate Chair (Undergraduate) in Mechanical Engineering.

Marilyn obtained her B.A.Sc. from Queen's University in Mathematics and Engineering followed by a Masters and Ph.D. from the University of Waterloo in Mechanical Engineering in the area of CFD. After obtaining her Ph.D., she joined Atomic Energy of Canada Limited as an analyst working in nuclear thermalhydraulics. While Marilyn enjoyed her work in the nuclear industry, she realized that an academic career was her long-term career objective. To enable this, she successfully applied for a NSERC Women's Faculty Award and joined the Mechanical and Industrial Engineering Department at the University of Toronto in a CLA position. She subsequently joined the Department of Mechanical Engineering at McMaster University.

Marilyn's research interests span three different areas within thermofluids. The most fundamental work is in the development of new mathematical models to predict the interaction of droplets or particulates with a turbulent flow. This has applications in areas such as combustion, environmental flows and drug delivery. Marilyn has also been active in the area of solar energy (her Master's thesis was on this topic) and thermal energy storage. She currently has an active group that is using computational and experimental methods to develop high-capacity thermal storage through the incorporation of phase change materials. Lastly, Marilyn has maintained collaborations with the nuclear industry through the University Network of Excellence in Nuclear Engineering (UNENE) on modelling nuclear subchannel flows. Thirty-three students have completed their graduate degrees with her and she is currently supervising or co-supervising nine graduate students.

Marilyn has been involved with a number of groups outside of McMaster. She was Executive Officer for the CFD Society of Canada and was a Director for the period 2003-2008 and was Co-Chair for the 15th Annual Conference of the CFD Society of Canada (CFD2007). Marilyn also was the National Fluids Examiner for the PEO for the period 2007-2010. She was a member of the NSERC Evaluation Group for Thermofluids for 2008-2011, was Co-Chair for that group in 2010-11 and was also a committee member for the Agence Nationale de la Recherche in France (France's NSERC equivalent) in 2011-12. She is currently a project leader for the Solar Net-zero Energy Buildings Research Network in the area of thermal storage. Marilyn has also been a volunteer with the Canadian Cancer Society and has been a co-chair of Bingo Night (a somewhat surprisingly huge job) for many years at her children's school. She lives in Toronto with her husband, two boys, and her elderly cat.

Q. Who inspired you to become a Mechanical Engineer?

A. As a child I was very interested in solar energy and I always knew that I wanted to work in science. I was also lucky to have an aptitude for mathematics and physics. When I was in high school, I took Grade 13 Physics one year early. One of the Grade 13 girls, who I really looked up to, was going to study Engineering at Queen's. So it was really my conversations with her that inspired me to consider applied rather than pure science. Engineering was also, of course, an excellent fit for my interest in solar energy. At the time though, high school guidance counsellors really did not know much about engineering and certainly were not encouraging women to consider it!

Q. Who (other than family members) do you admire most?

A. I am absolutely inspired by my graduate supervisors from University of Waterloo: George Raithby and Terry Hollands. They are both brilliant and have made extraordinary contributions to their areas, and yet remain modest. They were outstanding teachers to me and I feel that much of my success is a result of the learning that occurred during that time.

Q. What is your definition of leadership?

A. Leadership requires an ability to inspire co-workers to do the best that they can do by providing challenging and meaningful work, recognition of accomplishments, and opportunities for personal growth. A good leader is also someone who values honesty, accountability and kindness.

Q. What do you feel has been your most important professional accomplishment to date?

A. I believe that the greatest impact of the work that I do is through teaching undergraduate and graduate students and also through the counselling of undergraduate students that I did in my previous Associate Chair role.

Q. What is the one piece of advice you would give to Women in Engineering?

A. Don't wait to have babies! I waited until my mid-thirties because of my various career choices (grad school, then a few years in industry, joining academia in my early thirties...) and there was never a good time. So I recommend to our new-hires at McMaster that they really don't need to wait for tenure before starting a family.

Qiao Sun

Qiao Sun is a professor in the Department of Mechanical and Manufacturing Engineering at the University of Calgary. She leads her research group in the effort to improve the performance of mechanical systems for higher precision, speed, reliability, and energy efficiency. She also teaches at the undergraduate and graduate levels on subjects such as engineering mechanics, control systems, and optimization methods. She has been chosen by graduating classes as the "Professor of the Year" numerous times.

Qiao obtained her BSc in Power Machinery with a major in Marine Diesel Engines from Shanghai Jiao Tong University and worked as an engineer in a shipyard for one year before she returned to the same university to pursue a master's degree in Mechanical Engineering. She studied robotics for her MSc and went on to become a research engineer and lecturer at the Research Institute of Robotics of Shanghai Jiao Tong University. She was involved in the design and prototyping of China's first industrial robot Shanghai-No.1 where she obtained a tremendous amount of firsthand knowledge in motion control. She came to the University of Victoria in 1992 to pursue a PhD degree focusing on the dynamics aspects of flexible cooperating manipulators. Following the completion of her PhD, Qiao worked at the National Research Council of Canada in Vancouver for 8 months before she joined the University of Calgary in 1996.

Q. What's your day job?

A. I spend between 2 to 4 hours on teaching including lectures and labs, preparing notes, marking tests, answering questions from students, and managing materials on Blackboard; another 2 to 4 hours on research related activities such as reading and writing articles, attempting solutions with pencil and paper or computer, discussing interesting problems with graduate students/visiting scholars, and attending meetings; and another 1 to 2 hours on service related work such as reading and writing, and attending meetings.

Q. What's the best part of your job?

A. The best part of my job is the freedom I have to choose what I want to do in my research and to pursue what I feel is of value to my heart.

Q. What's the Favorite part of your career?

A. Teaching! Teaching is my way of contributing to the betterment of mankind and our society. I love to teach my students how to think and how to reason. I also highly value the influence of my role as a positive example of good work ethics and discipline for young people.

Q. Who inspired you to become a Mechanical Engineer?

A. My high school math and science teachers had the most influence in leading me to science and engineering. What made me choose engineering as opposed to science is the influence of a family friend who was also a university professor, an alumnus of Shanghai Jiao Tong University. He showed me pages and pages of ordered numbers called matrices that were part of a finite element calculation for structural analysis. I thought to myself that I would also like to learn to tackle problems that were close to everyday lives.

Q. What is your definition of leadership?

A. A leader is someone who can motivate and engage others in the pursuit of a vision. I see myself taking leadership roles in classrooms and in guiding graduate students to achieve learning goals. I also see ourselves, the engineering professionals, as having undeniable responsibilities to take leadership roles in dealing with the world's complex problems, such as health care, energy, and environment.

Q. What do you feel has been your most important professional accomplishment to date?

A. My most important professional accomplishment is that, as an engineering professor, I have taught a couple thousand undergraduate and graduate students. I truly feel accomplished when I shake their hands as they cross the stage at convocation each spring. I feel even more accomplished when they come back to tell me what they have been doing for work.

Q. If you had not chosen a career in engineering academia, what else would you have done?

A. I would probably be taking a position of research scientist in a research institute or a company. It is important that I have the freedom to find new ways of solving an old problem or to find new problems and challenges to tackle as my daily work.

Q. What's one piece of advice you would give to Women in Engineering?

A. If engineering is your passion, then go for it. It is true that women face challenges in this still male dominated field but positive changes are taking place. Seek advice from people who have experience or knowledge whenever possible.

Inna Sharf

Inna Sharf, currently a professor in the Department of Mechanical Engineering at McGill, received her B.A.Sc. in Engineering Science, specializing in Aerospace option, from the University of Toronto (1986). Upon completion of the degree, she immediately enrolled in a graduate program at the same institution. She was fast-tracked into a Ph.D. program, which she completed in Aerospace Engineering in 1991 at the Institute for Aerospace Studies, University of Toronto. Thereafter, in January 1991, Sharf joined the Department of Mechanical Engineering at the University of Victoria (UVic) as an Assistant Professor and holder of the NSERC's Women's Faculty Award. Sharf's research activities at that time were focused on the dynamics and modeling of flexible space manipulators, such as Canadarm. The ten years at UVic were interrupted by two maternity leaves in 1995 and 2000 and a sabbatical leave in 1997 which was divided between the Department of Aerospace Engineering at TU Delft (the Netherlands) and Faculty of Aerospace Engineering at the Technion (Israel). After returning to Victoria from sabbatical, Sharf started collaborating with MDA (former Spar Aerospace) on problems related to contact dynamics in space robotic applications: modeling, validation and identification. This led to a multi-year research program in this area, funded by MDA, the Canadian Space Agency (CSA) and NSERC. In the last two years of her appointment at UVic (1999-2001), Sharf worked in collaboration with astronomers at the Herzberg Institute for Astrophysics (NRC-HIA) on the design of a new experimental laboratory for the development of astronomical instruments. This resulted in a multi-million new initiative, which was lead by Sharf and funded through the CFI grant on the design and analysis of astronomical instrumentation.

In 2001, Sharf left University of Victoria to relocate to Montreal where she took up a position as Associate Professor at McGill. The move to another university provided Sharf a unique opportunity to rebuild her research program afresh. Re-energized by the move and motivated by the international efforts in the area of on-orbit servicing of satellites, Sharf started the construction of a unique facility for studying robotic grasping of satellites and debris in space. Since its inception in 2003 to present, the Aerospace Mechatronics Laboratory constructed with funding from NSERC, Canadian Space Agency, IRIS and PRECARN has supported the research of numerous graduate students, visiting trainees and undergraduate students.

McGill provided Sharf fertile ground for initiating new projects and collaborations with other colleagues at McGill, at other universities and government agencies. In 2008, Sharf took her second sabbatical in the Faculty of Mechanical Engineering at the Technion where she collaborated with several professors and students on modeling of biomedical devices.

The more recent and substantial collaboration led to her research on navigation and control of small unmanned aerial vehicles (UAVs), with funding from DRDC-Suffield. Sharf is presently participating in the NSERC Canadian Field Robotics Network, as a principal investigator in the group of 11 co-applicants from 8 Canadian Universities. Her contribution to this five-year initiative is to further develop autonomy for small rotary aircraft.

As an educator, Sharf has contributed to educating mechanical engineering students for the past 23 years, at all levels of training: undergraduate, Masters, PhDs, visiting trainees and summer students. She has taught many different courses in the areas of solid mechanics, dynamics, control systems and robotics to thousands of undergraduate students and hundreds of graduate students to date. Sharf is also active in serving three communities: (i) the scientific community through workshop and conference organization, editorial board memberships and peer review, (ii) the academic community in her department and University through service on academic committees and (iii) the community at large through outreach programs to high-schools, service on company board of directors, public talks and media interviews.

Q. What's the best part of your job?

A. The best part of my job is the opportunity to be constantly learning new things. I never stop learning and being exposed to new challenging technical and scientific problems, new information, and new technologies. I find this to be the most exciting part of my job.

Q. Who inspired you to become a Mechanical Engineer?

A. I was not really inspired to become a Mechanical Engineer per se, but rather to go to University of Toronto for a particular program: Engineering Science. I learned about this program from a friend of mine who was a year ahead of me in high school and ended up getting into Engineering Science at UofT. He told me about the program and it really appealed to me. The rest just unfolded naturally from then on: being in the right place at the right time.

Q. Who (other than family members) do you admire most?

A. I don't have a single person that I admire. I admire women who manage to have successful careers and balance that with family and personal life, raising children and being nice human beings. I have friends who have succeeded in doing so and I admire them.

Q. What do you feel has been your most important professional accomplishment to date?

A. Training and supervising my graduate students: this part of my job I value the most and I hope that I have contributed at least a bit to my graduate students successes and helped them launch their careers.

Q. If you had not chosen a career in engineering academia, what else would you have done?

A. I really don't know. At one point early on I thought of doing applied mathematics, then also working in industry. Looking back though, I think I am exactly in the right place.

Q. What's one piece of advice you would give to Women in Engineering?

A. Stick with it; be kind to yourself, don't try to compete with men in the profession, just try to do your personal best and enjoy the process, whatever it is.

Draganflyer X8 unmanned aerial vehicle being tested outdoors.

The 2014 CSME HAF Recipients Awarded at the CSME Congress 2014

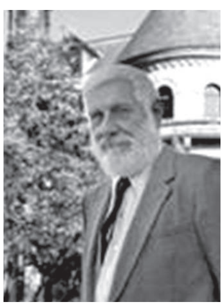
The Robert W. Angus Medal

Dr. Cristina H. Amon, Professor in Mechanical Engineering

Dean, Faculty of Applied Science and Engineering, UT

Dr. Amon is the Dean of Faculty of Applied Science & Engineering at University of Toronto. Dr. Amon has received numerous professional and leadership awards, including the ASME Gustus Larson Memorial Award, ASEE Westinghouse Medal, ASME Heat Transfer Memorial Award, and the Society of Women Engineers' Achievement Award. In 2012 she was recognized as one of Canada's most Influential Women. She was inducted to four academies: Canadian Academy of Engineering, Spanish Royal Academy, Royal Society of Canada and the U.S. National Academy of Engineering. She has authored over 350 refereed articles in education and research literature.

C.N. Downing award



Dr. Paul Zsombor-Murray, Professor in Department of Mechanical Engineering, McGill University

Professor Paul Zsombor-Murray is a professor in Mechanical Engineering at McGill University. His research interest is in Design and Manufacturing. He is the Fellow of the Canadian Society for Mechanical Engineers and the Editor of Transactions of the Canadian Society for Mechanical Engineers. Paul is awarded the C.N. Downing Award for his distinguished service to the CSME over the years.

I. W. Smith Award

Dr. Tobin Filleter, Assistant Professor in Department of Mechanical and Industrial Engineering, University of Toronto

Tobin Filleter is currently an Assistant Professor in the Department of Mechanical & Industrial Engineering at the University of Toronto. Dr. Filleter received a BSc (Eng.) in Engineering Physics from Queen's University (2003) and PhD in Physics from McGill University (2009). Professor Filleter's research interests are in nanomechanics and nanotribology.

Fellow of the CSME

Dr. Aimy. M.J. Bazylak, Associate Professor in Department of Mechanical and Industrial Engineering, University of Toronto

Dr. Chao Zhang, Professor in Department of Mechanical and Materials Engineering, The University of Western Ontario

Dr. Chris K Mechefske, Professor in Department of Mechanical and Materials Engineering, Queen's Universit

Dr. Craig A. Simmons , Professor in Department of Mechanical & Industrial Engineering, University of Toronto

2014 CSME HAF Awards

Fellow of the CSME (continued)

Dr. Zheng Hong (George) Zhu, Professor in Department of Earth and Space Science and Engineering, York University

Dr. Farrokh Janabi-Sharifi, Professor in Department of Mechanical & Industrial Engineering, Ryerson University

Dr. Homayoun Najjaran, Associate Professor in Okanagan School of Engineering at the University of British Columbia

Dr. Payam Rahimi, Senior Technical Officer at Ontario Power Generation,Toronto

Dr. John Joseph McPhee, Professor in Systems Design Engineering, University of Waterloo

Dr. Remon Pop-Iliev, Professor in Department of Automotive, Mechanical and Manufacturing Engineering, University of Ontario Institute of Technology

Dr. Mamoun Medraj, Professor in Department of Mechanical Engineering, Concordia University.

Dr. Sheldon Isaiah Green, Professor in Mechanical Engineering, UBC

CSME Best Paper in CSME Transactions

"INDOOR LOCALIZATION OF AN OMNI-DIRECTIONAL WHEELED MOBILE ROBOT"

Authors: Sasha Ginzburg and Scott Nokleby, Faculty of Engineering and Applied Science, University of Ontario Institute of Technologys

Energy Storage Comes Out of Hiding

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Energy storage is an often hidden – but nonetheless important – energy technology. It can enhance the performance of energy systems, and improve their efficiency, economics, reliability and environmental impact. It is also a key to facilitating the widespread use of many renewable energy resources. Consequently, energy storage, although utilized quietly at present, is likely to be increasingly and more overtly used in the future as pressures from energy costs, security of energy supply and environmental damage expand.

This growth in interest in energy storage was recently emphasized in Ontario, via that province's recent Long-Term Energy Plan, which calls for the procurement of 50 MW of energy storage capacity by the end of 2014. Consequently, an energy storage procurement framework was jointly submitted by the Independent Electricity System Operator (IESO) and Ontario Power Authority (OPA), and supported by the Minister of Energy in the province. The procurement framework allows for a diverse portfolio of energy storage technologies, so as to foster improved understanding of and experience with 1) the services energy storages can provide, 2) the benefits they bring to operations and 3) how storage can best be integrated into electricity markets. In Phase I of the procurement framework, released March 12, 2014, the IESO issued a request for proposals for up to 35 MW of grid energy storage capacity from various storage technologies that can provide ancillary and other grid services (e.g., energy time-shifting, transmission congestion relief).

Some of the benefits of energy storage, which often are quite significant, follow:

When energy demand varies significantly with time, energy storage allows peak energy demands to be reduced or shifted to periods of lower demand, often with significant economic advantages.

Energy storage is especially helpful for bridging periods between energy supply and energy demand, and reducing the mismatches between periods of energy supply and demand.

The performance of energy systems that incorporate intermittent energy sources is made much more effective through the use of energy storage.

Energy storage facilitates the utilization of many renewable energy sources which, due to their intermittent nature, are often not available when energy services are required. Wind and solar energy technologies, for instance, often benefit from having storages that allow the energy products to be held until needed, if they are not required when the wind is blowing or the sun is shining.

Increased operational performance flexibility can be provided through the utilization of energy storage.

Energy storage provides the opportunity to reduce use of fossil fuels and their associated environmental impacts.

A broad range of types of energy storage technologies and systems exists (see Figure 1). These can be separated into as chemical, electrical, thermal, thermochemical, mechanical and other classifications. Specific types of energy storage include battery storage, hydrogen energy storage, flywheel energy storage, compressed-gas energy storage, pumped storage, magnetic storage, capacitor storage, chemical storage, thermal energy storage (both sensible and latent), thermochemical energy storage, organic and biological energy storage, and others. Although much energy storage is mature and commercially available, new storage technologies are being actively investigated and improvements to existing ones continually sought. Some technologies are both commercial at present but also undergoing extensive research, e.g., thermal energy storage [1].

Energy storage can be utilized in a wide range of applications (see Figure 2). The main types of applications include utility and other electrical power systems, conventional and renewable power generation, renewable energy sources, transportation, heat pumps, building heating and cooling and district energy systems. The ability of energy storage to facilitate the efficient, effective and economic operation of renewable energy systems is particularly noteworthy, e.g., energy storage to improve solar power plants.

I recently edited a book covering various aspects of energy storage from several perspectives, and intended to provide a broad understanding of energy storage and appreciation of its importance and benefits [2]. Included in the book are descriptions of energy storage technology and systems, updates on the status of technological development of energy storage technology, and recent advances in energy storage technologies, systems and applications. The book is organized into several parts, mainly based on category of energy storage, which highlight the diversity of storage types and applications:

1. General energy storage concepts, technologies and methods, including an overview of energy storage technology and methods for evaluating the efficiencies of energy storage technologies and systems.
2. Hydrogen energy storage, including descriptions of hydrogen storage on such materials as magnesium hydride, porous materials and hydrogen-based compounds.

3. Electrical energy storage, including emerging energy storage technologies in utility power systems, water storage for storing electricity to facilitate renewable energy use, double layer capacitors for electrical storage, and energy storage technologies for future power systems.
4. Thermal energy storage, including descriptions of thermal storage media for solar thermal power plants, the performance of phase change materials and geothermal storage, and applications of thermal energy storage in building heating and cooling and district energy.
5. Thermochemical energy storage, including a description of thermochemical energy storage technology, analysis and applications.

The benefits of and need for energy storage make it of interest wherever energy is used throughout the world. The global interest in energy storage technologies and applications is evident from the chapters in the above mentioned book, which originate from several continents and ten countries: Canada, United States, Argentina, France, Italy, Denmark, Croatia, Iran, Japan and Thailand.

Another very interesting example of the growing importance of energy storage can be observed through the NSERC Smart Net-zero Energy Buildings Research Network (SNEBRN) (http://www.solarbuildings.ca), of which I am a member. SNEBRN is currently the major Canadian research effort in smart net-zero energy buildings and communities, bringing together 29 Canadian researchers from 15 universities, as well as experts from Natural Resources Canada, Hydro-Québec, and other industrial partners. International researchers are also participating in the SNEBRN. The aim is to develop the smart net-zero energy homes, commercial buildings and communities of the future. A net-zero energy building is defined as one that, in an average year, produces as much energy (electrical plus thermal) from renewable energy sources as it consumes. The vision of SNEBRN is to facilitate widespread adoption in key regions of Canada, by 2030, of optimized net-zero energy building design and operation concepts suited to Canadian climatic conditions and construction practices. Although various technologies are required in smart net-zero energy buildings and communities (e.g., building-integrated solar systems, high performance windows with active control of solar gains, heat pumps, combined heat and power technologies, smart controls), the SNEBRN vision almost certainly hinges on the use of energy storage technologies, ranging from short- to long-term. In fact, one of the five main themes of SNEBRN, of which I am co-leader, is on mid- to long-term thermal storage for buildings and communities.

It certainly appears to me that energy storage is not coming out of hiding and to the forefront, allowing energy storage technologies become more effective and applications to expand. I see this as a welcome development which will help humanity achieve better energy systems in all countries now and in the future.

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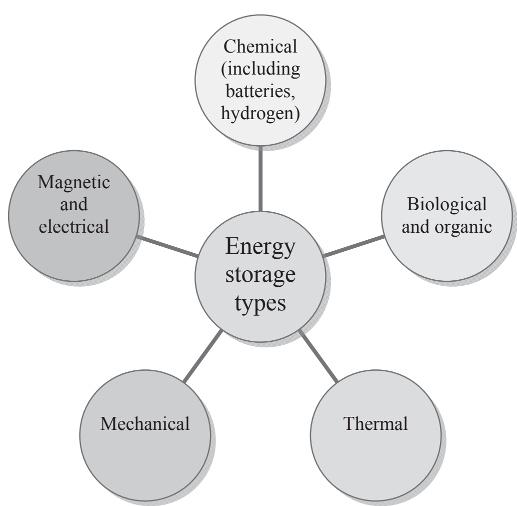

Figure 1. Energy storage types classified by type of stored energy.

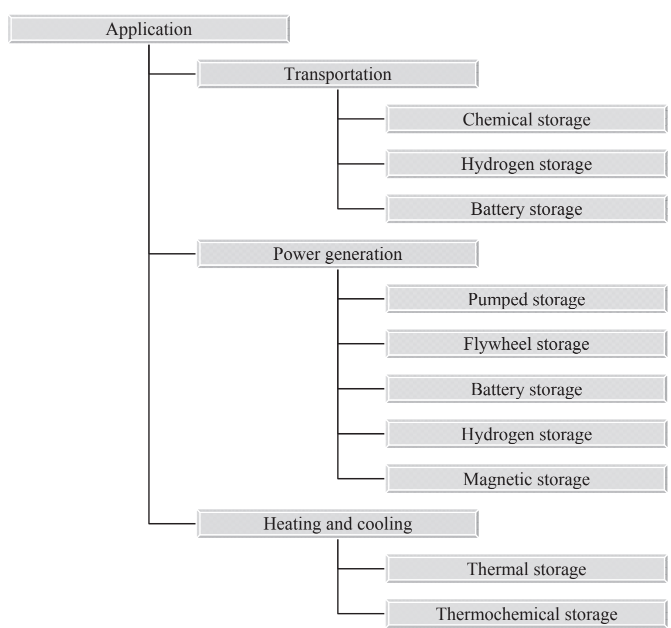

Figure 2. Selected energy storage application, based on area of utilization.

Micromechanics modelling of particle-reinforced metal-matrix composites

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1. Introduction

Particle-reinforced metal matrix composites (MMCs) are composites of a metal matrix reinforced with a nonmetallic, usually ceramic, or silicon carbides particles. Particles in MMCs are properly dispersed in order to provide advanced properties for the composites than the pure matrix metal material or the reinforcements. These property advantages include higher strength, ductility or thermal resistance, or strength-to-weight ratio, to name a few.

Particle-reinforced MMCs are generally classified into two groups depending on their dominant strengthening mechanisms: direct strengthening and indirect strengthening MMCs. Direct strengthening mechanism comes from load transfer from the matrix to the particles due to the distinct higher stiffness of particles in comparison with that of the matrix. Indirect strengthening comes from the microstructural effect of the particles usually exhibiting as dislocation strengthening, since the dispersed particles work as barriers to dislocation motion, leading to strength increasing. In fact, both strengthening mechanisms exist simultaneously in almost all MMCs.

Recent development in the steel making industry has resulted in a number of advanced high strength steels, whose microstructure shows a distinct martensite second-phase, or bainite third phase particles dispersed in the ferrite matrix. The effect of these reinforcement phases in the advanced high strength steels is analogous to the role of particle-distribution in the mechanical properties of particle-reinforced MMCs. Figure 1 shows an aluminum-silicon carbide MMC [1] and a dual-phase advanced high strength steel microstructure [2].

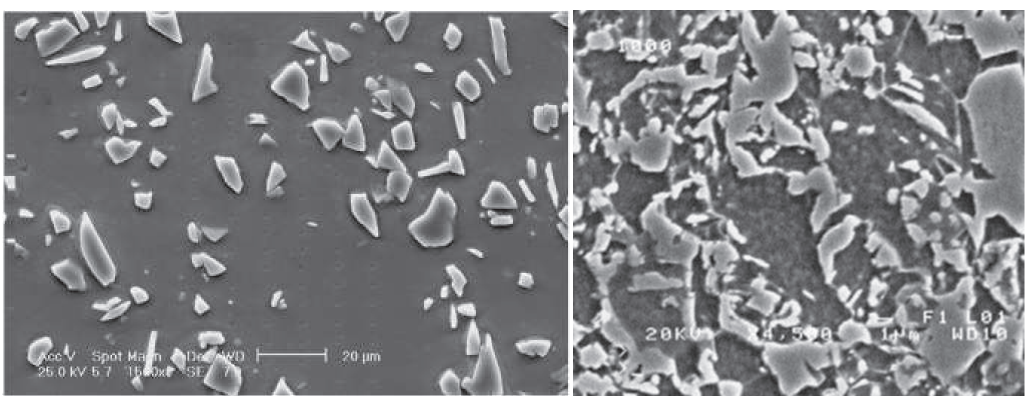

Figure 1 Microstructure of an aluminum-silicon carbide MMC (left) [1] and dual-phase steel (right) [2] where SiC and martensite particles disperse in the aluminum and ferrite matrices.

Micromechanics modelling of the strengthening mechanism of particle-reinforced MMCs has become an active research topic since the classical Eshelby model was proposed in the 1950s [3]. The Eshelby model is also known as the equivalent inclusion theory in which the second-phase inclusion was replaced by an identical volume of matrix undergone certain volumetric strain, or the so called eigenstrain, to reflect the difference in the physical properties of the matrix and inclusion. This strain will lead to deformation of surrounding matrix when the equivalent volume is placed back into the matrix. The eigenstrain theory is very versatile as it can easily be extended to problems where phase transformation, plastic deformation, or a fictitious source could result in such a strain.

The accumulated research in this area is so huge that it would be impossible to summarize a fraction in this short article. Interested readers are referred to reviews in [4, 5]. As a result, the current article will focus on some recent progress in micromechanics modelling of the effect of particle distribution on the properties of MMCs, in particular, the challenging features such as particle size, shape, and particle clustering.

2. Particle size, shape and damage

2.1 Particle size

Particle size and shape are local parameters which usually cannot be considered in the models based on the extended equivalent inclusion theory or average field theory [3, 4]. This is because these theories lack of an intrinsic length scale. An alternative approach to examine the effect of particle distribution on MMCs is dislocation-based [6-8], as well as strain gradient plasticity models [9-11]. Particle size dependence is accounted for in these methods and the indirect strengthening of particles as dislocation barriers can be evaluated. Recent results show that these models lead to a smaller increase in the flow stress in comparison to experiments because of the load transfer mechanism is missing [12]. Naturally a combined or hybrid model has been proposed to account for both direct and indirect strengthening mechanisms in particle-reinforced MMCs. Nan and Clarke [13] extended the average field theory by introducing a characteristic length scale according to dislocation plasticity. Dai et al. [14] proposed a hybrid model by combining dislocation theories and micromechanics model. Tohgo et al. [15] improved the incremental damage model of MMCs to account for particle size effect using the Nan-Clarke model.

Recently, Abedini et al [16] proposed a hybrid model combining a tangent-based method of homogenization and a dislocation plasticity method for an elasto-plastic metal matrix reinforced with elastic, spherical particles. The inherent lack of a length scale is overcome by introducing dislocation plasticity into the stress-strain relation of the tangent-based model. For verification purposes, the results are compared with the experimental results of uniaxial tensile tests on the MMCs of different particle sizes [17].

In the numerical algorithm, the incremental constitutive relation was adopted. The stress increment for a particle can be obtained directly by Hooke's law

$$\langle \Delta\sigma \rangle_I = \mathbf{C}_I : \langle \Delta\varepsilon \rangle_I \tag{1}$$

This stress increment will be added to the total stress of the particle from the previous step to form the new stress tensor.

The current stiffness of the elasto-plastic matrix, C^{ep}, is obtained from the classical theory of J_2 elasto-plasticity:

$$\mathrm{C}^{ep} = \mathrm{C}^{el} - \frac{(2\mu)^2}{h} \mathrm{N} \otimes \mathrm{N} \tag{2}$$

where the elastic stiffness matrix, C^{el}, is obtained from the following incremental stress-strain relation [18] and N is the normal to the yield surface in stress space.

The complexity of numerical implementation of the incremental algorithm is compensated by its capability of handling loading history and non-proportional loading (e.g. cyclic deformation) on the mechanical behavior of composites [18].

Particle size effect can be accommodated in the model using the Nan and Clarke method [13]. In the plastic region, the overall flow stress of the matrix, σ^m, can be obtained by modifying the yield stress of the matrix as

$$\sigma^m = \sigma_y^m + \Delta\sigma^m \tag{3}$$

where σ_y^m is the yield strength of the unreinforced matrix and $\Delta\sigma^m$ is the dislocation strengthening effect due to the presence of the particles. The dislocation strengthening effect can be determined as [13]

$$(\Delta\sigma^m)^2 = (\Delta\sigma_{OR}^m + \Delta\sigma_{KIN}^m)^2 + (\Delta\sigma_{ISO}^m)^2 \tag{4}$$

where $\Delta\sigma_{OR}^m$ is caused by the resistance of closely spaced hard particles to the passing of dislocations and is called Orowan stress, and the additional terms on the right hand side represent the contribution to the flow stress from isotropic and kinematic strain gradients which also related to particle size[13]. The Orowan stress can be obtained by

$$\Delta\sigma_{OR}^{m} = \alpha\frac{\mu^{m} b}{L} \tag{5}$$

where α is a constant, μ^{m} is the elastic shear modulus of the matrix, b is the Burger's vector of the metallic matrix, and L is the mean particle spacing, which is related to the particle size and volume fraction [13]. Figure 2 shows the modelling results in comparison with the experiment and good agreement has achieved for the model material.

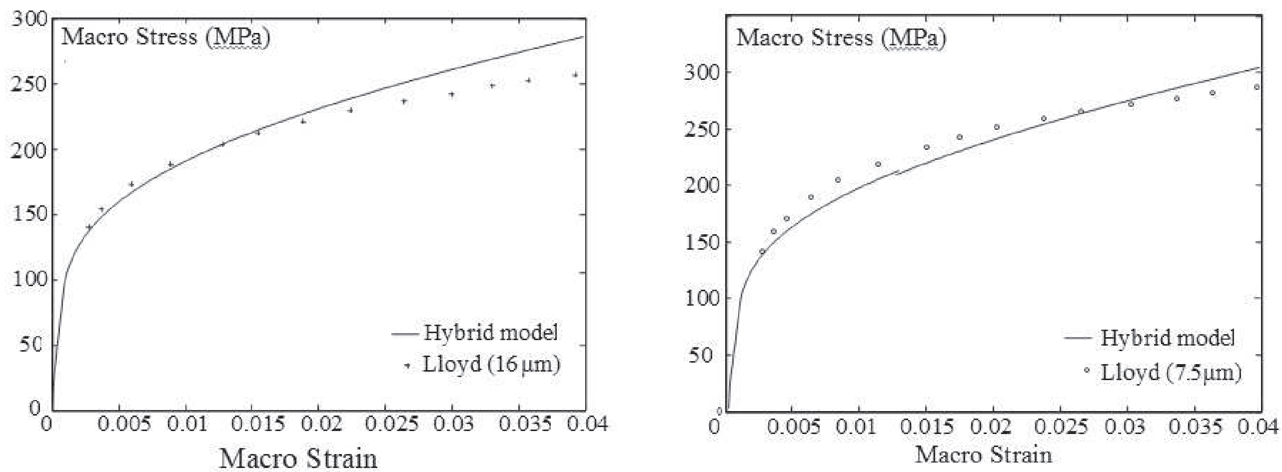

Figure 2 Particle size effect predicted by the hybrid model in comparison with the experimental results [18]. The experimental results were obtained for an aluminum alloy matrix reinforced by SiC particles of 15% volume fraction with two different particle sizes: 7.5 and 16 [17].

2.2 Particle damage

Hard, brittle particles are more likely to fracture or debond from the ductile matrix in MMCs. For simplicity, it is appropriate to introduce a stochastic distribution function such as the Weibull function [18] to account for the probability of particle fracture for a uniform particle population. Then the actual particle volume fraction will decrease accordingly with straining to account for the effect of particle damage. Some recent results [17] are presented in Figure 3 to show the effect of particle damage on the mechanical response of particle-reinforced MMCs using the Weibull function to account for the probability of particle cracking and its effect on the macroscopic response of MMCs. It is clear that the modified model provides better predictions than the model without consideration of particle damage.

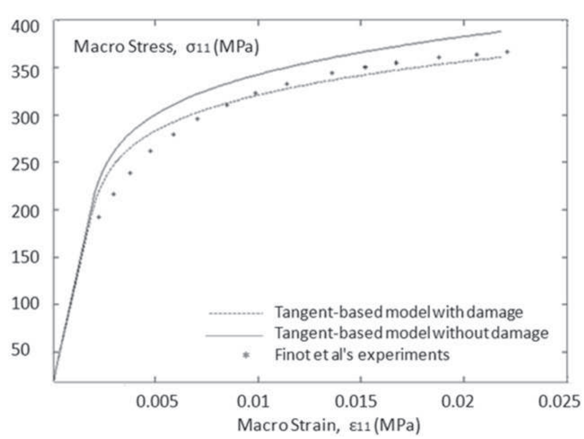

Figure 3 Effect of particle damage on the predicted stress-strain relation of MMCs using the hybrid model [19].

2.3 Particle shape

Particle shape effect, unlike size effect, can be examined both by homogenization method and finite element method. The original Eshelby tensor which measures the elastic response of the inclusion-matrix system to the eigenstrain was obtained based on an ellipsoidal inclusion. Figure 4 shows the effect of particle shape in terms of particle aspect ratio on the uniaxial behaviour of MMCs [19]. A higher aspect ratio always exhibits higher strength when the load is aligned in the direction of the major axis of particles.

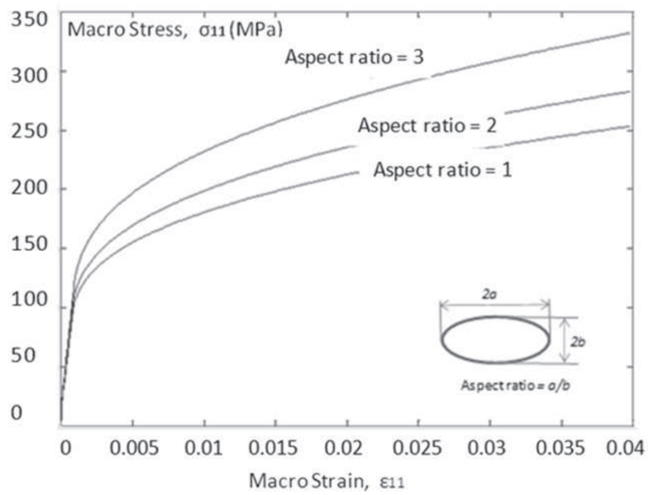

Figure 4 Effect of particle shape on the predicted stress-strain relation of MMCs. The uniaxial load is applied in the direction parallel to the major axis of the elliptical particles [19].

3. Particle clustering

In particle reinforced MMCs, particles are not necessarily distributed uniformly in the metal matrix. Rather, they are clustered as Figure 1 shows. Understanding how particle clustering affects mechanical properties of MMCs quantitatively is essential to optimization of microstructure design. Traditional average field methods based on Eshelby model [3-5] couldn't account for particle clustering and the results are usually expressed in terms of particle volume fraction. Recently, Abedini et al [18] used finite element method to simulate the effect of particle clustering on the general mechanical behaviour of MMCs. Figure 5 shows three different particle cluster geometries namely linear, planar and spherical clusters, which were adopted from the work of Thomson et al. [20] who used the same geometry to investigate void clustering effect on ductile fracture.

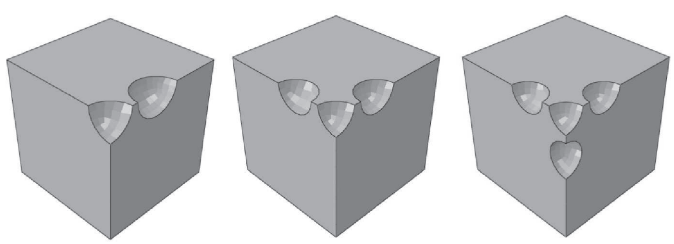

Figure 5 Linear, planar, and spherical particle clusters from left to right [18]. In the linear cluster, three particles align linearly in the unit cell; in the planar cluster, five particles align in the central horizontal plane of the unit cell; while in the spherical cluster, seven particles form a spherical structure with one as the center. These geometries were first proposed by Thomson for void clustering in metals [20].

The effect of particle clustering on the local stress around the center particle in particle clusters is displayed in Figure 6, where linear cluster shows the highest maximum principal stress. In other words, of all the clustering geometries considered, linear cluster would most likely lead to particle cracking and nucleate microvoids, which ultimately degrades the material and lead to lower strengthening effect than the other cluster geometries. It is consistent with the experimental observations.

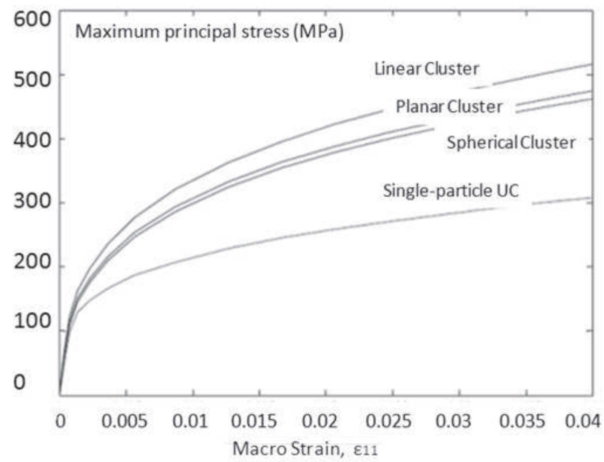

Figure 6 The maximum principal stress in the middle particle for the different cluster models with cluster density of k = 18 [18], where k is defined as the ratio of inter-cluster spacing to particle spacing within a single cluster. A higher value of k represents a denser clustering of particle distribution.

4. Summary

This article summarized some recent results on micromechanics modelling of particle-reinforced MMCs. The effect of complicated features of particle distribution, such as particle size, shape and clustering, as well as particle damage on the macroscopic behaviour of the composite is exhibited as valuable reference to materials scientists to optimize microstructure for better mechanical properties.

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Sustaining Sustainability

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Sustainability has been an increasingly important focus in recent years to the engineering profession, as well as to such constituencies as government, industry and business, the public and educational institutions. In an effort to sustain efforts on sustainability, the 3rd World Sustainability Forum (WSF) (http://sciforum.net/conference/wsf3) was held 1–30 November 2013, attracting papers from more than 160 authors from around the world. This electronic conference was held virtually on the platform sciforum.net, and covered many recent advances and contributions to sustainability and sustainable development. These are presented and discussed in this article, along with an overview of the Forum.

Sustainable engineering is receiving increasing attention as time passes, as are sustainable design trends. For instance, sustainability applications in engineering are being reported in energy, infrastructure, design, materials and manufacturing.

Approach

To allow the latest work in sustainability from across the world to be exchanged by scientific engineering and other experts, while accommodating busy work schedules, funding limitations and desires to make conferences more environmentally benign, an electronic conference is advantageous. The World Sustainability Forum has followed this approach over the last three years. Timely, rapid, direct, yet flexible, communications of ideas and information are facilitated through this virtual approach, which facilitates presentations of research papers – ranging from theoretical to practical – and critical discussions from the numerous disciplines associated with sustainability.

Discussions about the conference topics were carried out through a mailing list for the 3rd WSF, and were driven particularly around topics related to the environment, resources and future scenarios.

The many advances and contributions reported on sustainability and sustainable development were focused around the following technical and non-technical areas, which reflect the multi-disciplinary nature of the subject:

- Environmental sustainability
- Energy efficiency and renewable energy sources
- Corporate sustainability strategy
- Social values for a sustainable economy
- Sustainable urban development
- Sustainable agriculture and sustainable management of land and biodiversity
- Sustainability entrepreneurship and sustainability innovation
- Sustainable development policy, practice and education

Advances in Sustainability

Selected advances reported in research years are summarized in the next section, broken down by the areas listed above. All of these advances are described in papers from the 3rd WSF and reported online at the conference web site.

Numerous contributions to environmental sustainability have been reported, including many dealing with life-cycle assessments of anthropogenic and natural systems and processes. Sustainable use of resources is also attracting researchers, as is the sustainable food systems and tourism. Efforts are also ongoing to address environmental topics from a socio-economic perspective, to improve the acceptability of environmental measures.

Much work is underway on improving energy efficiency and exploiting renewable energy sources, so as to make energy use and systems sustainable. Renewable energy and efficiency advances are being reported on energy efficient buildings; waste heat recovery; solar, geothermal and other less environmentally intrusive energy forms; and alternative fuels (e.g., bioethanol). As Chair of the World Sustainability Forum and Editor-in-Chief of the journal Sustainability, the present author addressed trends, needs and future directions for energy research for sustainability, through a recorded a keynote presentation for the conference (available online).

Developments are also being reported on corporate sustainability strategies. A notable effort investigates self-directed management and assessments of how national projects for sustainability can be enhanced and made more acceptable through the involvement of local stakeholders.

Topics being investigated in the area of social values for a sustainable economy are particularly concerned with the social values of sustainable community practices. Numerous case studies have been reported highlighting impacts of social values. Other contributions have been made relating to archaeology and sustainability ties in the Brazilian Amazon, sustainable consumption, and linkages between sustainable healthcare and health consumer discourses.

Advances have been made in sustainable urban development. Particular successes have been made in smart and sustainable urban city design, sustainable local energy supply methods and sustainable domestic water use systems.

Advances have also been made on sustainable agriculture and sustainable management of land and biodiversity. For instance, strategies and tools for sustainable agriculture and farming have been assessed, while sustainable practices for concrete have been made.

In the field of sustainable entrepreneurship and sustainability innovation, opportunities and challenges have been investigated as they relate to developing sustainable innovations. Studies have been reported on using universities and other educational institutions as economic drivers of technological innovation related to sustainability. For instance, a project has been reported on the installation of photovoltaics in Tongan schools, in partnership with various Tongan stakeholders.

Contributions have been made recently by many researchers on policy, practice and education related to sustainability and sustainable development. For instance, the centrality of sustainable well-being of humans has been studied, while barriers to implementing sustainability measures at educational institutions have been examined, from the perspectives of various stakeholders. Much of this work has also focused on projects incorporating sustainable development practices. For example, the manner in which a country like Nepal addresses its rapid development from a sustainability perspective has been investigated generally, while specific programs in that country (e.g., a Latrine Program) have received focused attention.

Closure

Numerous advances have been made on sustainability and related issues in recent years. Much of this work can be divided into the areas shown in Figure 1. Many of the advances relate directly or indirectly to engineering, although the multidisciplinary nature of sustainability necessitates advances in many other fields. Despite the barriers that exist to enhancing sustainability utilization by engineers, a focus on the implementation of sustainability concepts, actions and measures in engineering appears to be developing. The numerous advances discussed herein are evidenced well by the papers published and presented at the 3rd World Sustainability Forum, an e-conference which provided a forum for participants to examine, explore and critically engage with issues and advances in sustainability.

The 4th World Sustainability Forum (http://www.sciforum.net/conference/wsf-4) was announced in May 2014, and will occur 1–30 November 2014, with the intent of providing a forum to sustain efforts on sustainability. It will be organized into sections following those listed in Figure 1. The event hopes to facilitate further discussions and peer exchange, expand the disciplines addressing sustainability, and provoke debates in all areas of sustainability where consensus opinions are lacking.

Figure 1. Many of the topics comprising sustainability.

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