Prof. Andre McDonald, Peng., CEng, PE, FASM, FIMMM, FIMechE
Trustee (2022-2025)

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Dr. André McDonald is a Professor in the Department of Mechanical Engineering and the immediate past Associate Vice President (Strategic Research Initiatives and Performance) at the University of Alberta. He received his BSME in 2001 and his MSME in 2002 from the City College of New York. He was awarded his Ph.D. from the University of Toronto in 2007, under a collaborative research program with the National Research Council Canada in Boucherville, Québec. Dr. McDonald has more than twenty years of experience in the fabrication, development, and performance assessment of thermal- and cold-sprayed coatings. His current research involves the development of multi-functional coatings that provide wear and erosion resistance, heating, and structural health monitoring to a variety of structures. Modelling work to predict and analyze the performance of coatings is a focal feature of his research program. In addition to peer-reviewed scientific articles, Dr. McDonald has published a textbook on the practical design of thermo-fluids systems, a manual for thermal spraying for the Oil & Gas industry, several book chapters on thermal-sprayed coatings, and numerous industry reports. He has received several awards including the Jules Stachiewicz Medal from the Canadian Society for Mechanical Engineering for Heat Transfer, Fellow of The Institute of Materials, Minerals and Mining, Fellow of ASM, Fellow of The Institution of Mechanical Engineers, Fellow of the Canadian Society for Mechanical Engineering, the Mentorship Award from the Faculty of Engineering (University of Alberta), and the Association of Professional Engineers and Geoscientists of Alberta's Early Accomplishment Award. He holds Professional Engineer licenses in Canada (Alberta) and the United States (California) and is a registered Chartered Engineer in the United Kingdom. Dr. McDonald has trained over 100 students, fellows, and research associates in the areas of thermal spraying and heat transfer. Among many other leadership contributions, he was chair of the Natural Science and Engineering Research Council (NSERC) Scholarships and Fellowships Selection Committee – Civil and Mechanical Engineering and is currently the Editor-in-Chief of the *Journal of Thermal Spray Technology* and Past President of the ASM Thermal Spray Society Board. He currently leads the Experiential Learning in Innovation, Technology, and Entrepreneurship (ELITE) Program for Black Youth – an externally funded university-government-industry-community collaboration to support hands-on learning and work-integrated training of Black Youth in science, technology, engineering, and mathematics (STEM) fields and in entrepreneurship.

Abstract: Development and Performance Modeling of Heating Coatings

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Abstract:
The development of embedded de-icing elements for polymer-based composite materials, coupled with mathematical models that describe their performance, is of interest to the aerospace, communications, energy, and pipe transport sectors. Nickel alloy-based heating coatings were deposited on to fiber-reinforced polymer composite (FRPC) plates and low carbon steel pipes by using a flame spraying process. Electric current was supplied to the coatings to generate energy by way of Joule heating (or resistive heating) to enable the coatings to act as heating elements. De-icing tests were performed at sub-zero ambient temperatures. Heat transfer models were developed to predict the heating and melting times of the ice during the de-icing process with the flame-sprayed coatings. The models were based on the separation of variables method for a finite length-scale melting problem and Stefan's problem applied to a semi-infinite medium. It was found that a coating that was on the order of 100 µm thick was effective for melting accumulated ice. The results of the finite length-scale model and its agreement with experimental data suggest that a heat conduction model based on the separation of variables method may be applied to free boundary problems to predict phase change phenomena induced by thermal-sprayed coatings in a number of substrate geometries.

Abstract: Wear Mechanisms and Damage of Cold-sprayed Metal Matrix Composite Coatings

Abstract:
This program explored the effects of reinforcing particle content and microstructure on the mechanical properties and failure of low-pressure cold spray fabricated tungsten carbide-nickel (WC-Ni) metal matrix composite coatings. Image analyses were performed on scanning electron microscope micrographs of the coatings to characterize the microstructure and measure the total interfacial area between the reinforcing WC particles and the Ni metal matrix, the mean free path between the particles, the average particle size, and the porosity of the coating. Uni-axial quasi-static tensile testing was conducted on the as-sprayed coatings. The tensile stresses that were measured were coupled with the evolving strains that were calculated by using the digital image correlation (DIC) technique. The results showed that mechanical properties, namely tensile strength and Young's modulus, of the composite coatings increased with increasing WC content in the coatings. A framework was presented to elicit the micro-macro relationships between the microstructure and the tensile strength of the cold-sprayed composite coatings. Based on the developed framework, two distinct coating mechanical strength regimes were observed, indicating a significant increase in the tensile strength of the coatings that were comprised of more than 30 wt.% WC due to the refined microstructure of the coatings. The higher value tensile strength regime was also confirmed by the larger average mechanical energy absorbed to failure under tensile loading and lower damage accumulation. This collection of data of mechanical properties and the microstructures presented in this study

are important to validate numerical-based failure models for cold-sprayed composite coatings. Altogether, the results of this study will enhance understanding of the sensitivity of mechanical response of a composite coating to microstructural changes and expand to other materials systems including aluminum-alumina composite coatings.