Interfacial thermal-fluids problems involve the fluid dynamics and heat transfer at solid-liquid-gas interfaces. These phenomena happen in many engineering systems, such as fluid flow in a pipe, boiling water in a thermal power plant and ice on a vehicle's windshield or on marine vessels. Dr. Xili Duan is a mechanical engineering professor in Memorial University's Faculty of Engineering and Applied Science. His research aims to develop a better understanding of the interfacial thermal-fluids problems and advanced technologies to improve the efficiency and reliability of many energy systems. Dr. Duan's research involves the following two long-term research programs.

Interfacial Thermal-Fluids Research for Energy and Harsh Environment Applications

**Phase change heat transfer and materials for energy storage, conversion and thermal management applications**

Dr. Duan develops enhanced heat-transfer techniques in solid-liquid phase change and two-phase flow convection by combining macroscale enhancement elements, such as fins, with nanoparticles dispersed in the fluid or phase change materials (PCMs).

His research team studies the preparation, stability and thermal properties of the enhanced materials, such as nanofluids and nano-enhanced phase change materials (NePCMs), through experiments and numerical simulations. The team then develops the NCPCM, which is an advanced composite PCM with nanoparticles and paraffin wax in a ceramic porous medium fabricated from iron ore tailings. The NCPCM was tested and showed outstanding stability, thermal conductivity and energy storage capacity.

For applications, prototype thermal energy storage units have been built and tested in the lab for solar thermal storage and waste heat recovery. A hybrid thermal insulation technology with PCM and aerogel was developed for flow assurance in subsea pipelines. Most recently, Dr. Duan filed an invention disclosure for a technology that will directly convert wind to thermal energy.

This research program is supported by several grants including a Natural Sciences and Engineering Research Council of Canada (NSERC) Discovery Grant, an NSERC Engage Grant and research funds from Memorial University.

**Repellent Surfaces for harsh environment applications**

This research program involves the development of repellent surfaces, hydrophobic and/or icephobic, for asset integrity and engineering safety in harsh marine environments. The research team aims to develop surfaces that can mitigate problems such as corrosion of subsea and floating equipment or icing on offshore platforms. The research outcome from this program has tremendous potential of applications in energy exploration, ocean transportation, power transmission, among others, in the Arctic and offshore regions.

Hydrophobic and super-hydrophobic surfaces are being developed for realistic engineering materials, such as stainless steels, by incorporating micro/nanoscale roughness with low-energy coatings. The team investigated various mechanical and electrochemical methods to fabricate metal surfaces with microscale and submicron texturing and used low energy coatings to further improve the liquid repellency of these surfaces. Surface wettability was characterized by measuring the static and dynamic contact angles, as well as liquid drop sliding and adhesion on inclined surfaces. Corrosion resistance of the materials was tested in harsh environments with variable temperatures and water salinities. The group developed several metal surfaces that have almost perfect water repellency. They also developed new methods to characterize surface wettability and useful correlations between surface wettability and water icing time.

This program received major research fund from Petroleum the Research Newfoundland & Labrador (PRNL) and the Newfound provincial government.

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**Dr. Xili Duan, PhD**

Dr. Xili Duan is an Assistant Professor in Mechanical Engineering in Memorial University’s Faculty of Engineering and Applied Science. Before joining Memorial, Dr. Duan worked with Siemens Energy as a gas turbine combustion testing and design engineer for three years. He received his PhD degree from the University of Manitoba and completed postdoctoral work at the Massachusetts Institute of Technology (MIT). Dr. Duan’s current research interests include phase-change heat-transfer, flow-drag reduction and developing surfaces with special wettability for energy applications. He has published one book, one book chapter and over 60 journal and conference papers.