UNIVERSITY OF MARYLAND

THE BURGERS PROGRAM FOR FLUID DYNAMICS
THE FLUID DYNAMICS REVIEWS SEMINAR SERIES

MULTIPHASE BOUNDARY LAYERS IN CONTEXT OF FRICTIONAL DRAG REDUCTION

Friday, March 3, 2023 | 11am

DeWalt Seminar Room
2164 Glenn L. Martin Hall

Speaker

DR. SIMO A. MÄKIHARJU

Assistant Professor and Director of the FLOW Laboratory
Department of Mechanical Engineering
University of California Berkeley

ABSTRACT

Frictional drag can account for more than half of the resistance of a ship, and hence techniques to reduce it can have a significant impact in decreasing fuel consumption and emissions. Air lubrication was first proposed over a century ago. However, early on it produced mixed results due to the complex flow physics of multiphase boundary layers which we are only now beginning to understand sufficiently well to implement air lubrication on full-scale ships with confidence. Data from sea trials and from commercial ships in normal operation indicate that net fuel consumption can be reduced by 4 to 8% with Air layer Drag Reduction (ALDR). However, these realized net energy savings are only half to a quarter of the reduction in the required propulsive power, as the energy required by compressors to supply the gas is significant. On the other hand, superhydrophobic surfaces (SHS) do not require continuous gas injection, but SHS alone have not been successfully implemented at full scale due to challenges on durability, gas loss from plastrons and roughness. However, it was recently shown by FLOW lab that SHS combined with macroscopic air layers can enable maintenance of continuous gas layers with gas fluxes less than half of those required on hydrophilic surfaces. Experimental study of this multiphase flow over a complex surface, SHS-ALDR, and related phenomena are ongoing. Data are being used to derive a new model for critical gas flux, one that explains both roughness and surface contact angle dependence. It is intriguing to contemplate the potential for macroscopic air layers on superhydrophobic surfaces, if as indicated by small scale experiments the net energy savings of ALDR alone could be nearly doubled.

BIO

Simo A. Mäkiharju is an Assistant Professor at UC Berkeley. Mäkiharju's undergraduate studies were in Energy Technology at the Lappeenranta University of Technology, Finland. He received his Mechanical Engineering M.Sc. from the Ohio State University, and his Ph.D. from the University of Michigan. His graduate research focused on the reduction of hydrodynamic drag by gas injection and the development of a time-resolved X-ray densitometry imaging system for the study of multiphase flows. He continued at the University of Michigan as a Post-Doctoral Research Fellow (2012-2014) and as an Assistant Research Scientist (2014-2015) investigating single- and multiphase flow mixing in channel flows while continuing the development of X-ray based 2D and 3D flow measurement techniques.

In 2016 he started as an assistant professor at UC Berkeley and has continued pursuing his research interest in advancing the physical understanding of high-Reynolds number single- and multiphase flows through experimental research, primarily through the development and use of advanced experimental techniques. Mäkiharju's recent findings showed the feasibility of in-lab X-ray PIV experimentally and numerically, reveal fracturing during cavitation in shear thickening fluid, and consider air lubrication for drag reduction on engineered surfaces with supporting simplified experiments examining water impingement on engineered surfaces in parameter regime where gravity, surface tension and inertia are all important.

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