University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

BABAK MANOUCHEHRINIA

MSc (University of Nottingham, England, 2012)
BSc (University of Azad, Iran, 2010)

"Modeling, Optimization and Environmental Assessment of Electrified Marine Vessels"

Department of Electrical and Computer Engineering

Thursday, December 13, 2018
10:00 A.M.
Engineering and Computer Science Building
Room 468

Supervisory Committee:
Dr. T. Aaron Gulliver, Department of Electrical and Computer Engineering, University of Victoria (Co-Supervisor)
Dr. Zuomin Dong, Department of Mechanical Engineering, UVic (Co-Supervisor)
Dr. Panjotis Agathoklis, Department of Electrical and Computer Engineering, UVic (Member)

External Examiner:
Dr. Roydon Fraser, Department of Mechanical and Mechatronics Engineering, University of Waterloo

Chair of Oral Examination:
Dr. Lynda Gagné, School of Public Administration, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

Electrified vehicles (EVs), including hybrid electric vehicles (HEVs) and pure electric vehicles (PEVs), can provide substantial improvements in energy efficiency, emission reduction, and lifecycle cost over conventional vehicles solely powered by internal combustion engines (ICE). Progress on electrification of marine vessels has been made, but the pace has been impacted by factors such as different operational load profile of vessels, relatively small production levels and longer or varied lifetimes. In this dissertation, hybrid electric and pure electric propulsion system designs for fishing boats and passenger ferries are studied based on in-field acquired operational data. A new integrated marine propulsion system modelling and simulation method and a dedicated mobile data acquisition system have been introduced to analyse the energy efficiency, emission reductions, and lifecycle costs of a new or retrofitted fishing boat and passenger ferry with hybrid electric and pure electric powertrains. Following the automotive industry model based design (MBD) approach, modelling and simulation of electrified vessels using the acquired operation profile have been carried out using backward and forward-facing methods. Series hybrid electric and pure electric powertrain system designs with powertrain component models and rule-based system control, including properly sized electric ESS with a supercapacitor (SC) or battery, have been studied. The total CO_2 equivalent (CO_{2e}) or greenhouse gas (GHG) emissions and lifecycle costs of various new, electrified vessel propulsion system designs have been evaluated. Clean propulsion system solutions for fishing boats and passenger ferries with detailed powertrain system and control system designs which provide foundation for further research and development.

This dissertation also addresses the environmental impact of natural gas (NG) as a transportation fuel, particularly for marine transportation use. A systematic evaluation of Greenhouse Gas (GHG) emissions is provided for the upstream fuel supply chain of natural gas fuel in British Columbia (BC), Canada. The liquefied natural gas (LNG) lifecycle GHG emissions produced in both the upstream supply chain and the downstream vessel propulsion use are estimated quantitatively using manufacturer data and propulsion system models of marine vessels. Extensive data have been collected from oil and gas companies that have active operations in BC to determine the upstream supply chain GHG emissions of the NG fuel under three scenarios. The energy efficiency and emissions of natural gas engines are compared with traditional diesel fuel marine engines and generators. The results obtained indicate that LNG fuel results in 55% lower CO_{2e} with reduced local air pollutants such as sulfur oxides and particulates, compared to conventional diesel fuel. However, engine methane slip during combustion should be monitored as it can have a significant impact on the GHG emissions and so can offset the environmental benefits of LNG.