Notice of the Final Oral Examination
for the Degree of Master of Applied Science

of

SIYANG LIU

BEng (University of a, 1994)


Department of Mechanical Engineering

Monday, December 21, 2020
10:00 A.M.
Remote Defence

Supervisory Committee:
Dr. Zuomin Dong, Department of Mechanical Engineering, University of Victoria (Supervisor)
Dr. Brad Buckham, Department of Mechanical Engineering, UVic (Member)

External Examiner:
Dr. Jens Bornemann, Department of Electrical and Computer Engineering, UVic

Chair of Oral Examination:
Dr. Juergen Ehlting, Department of Biology, UVic

Dr. Stephen Evans, Acting Dean, Faculty of Graduate Studies
Abstract

Transportation is a primary pollution source contributing to 14 percent of global greenhouse gas emissions, and 12 percent of transportation emissions came from maritime activities. Emissions from the ferry industry, which carries roughly 2.1 billion passengers and 250 million vehicles annually, is a major concern for the general public due to their near-shore operations. Compared to the rapidly advancing clean automotive propulsion, fuel efficiency and emissions improvements for marine vessels are more urgent and beneficial due to the significantly higher petroleum fuel consumption and heavy pollutants and the relatively slow adoption of clean propulsion technology by the marine industry. Hybrid electric propulsion, proven to be effective for ground vehicles, presents a promising solution for more efficient clean marine transportation. Due to the diversified hull/propulsor design and operation cycle, the development of a hybrid electric marine propulsion system demands model-based design and control optimization for each unique and small batch production vessel. The integrated design and control optimization further require accurate and computation efficient hull resistance and propulsor thrust calculation methods that can be used to predict needed propulsion power and gauge vessel performance, energy efficiency, and emissions. This research focuses on improving the low-order empirical hull resistance and propulsor thrust models in the longitudinal direction by extracting model parameters from one-pass computational fluid dynamics (CFD) simulation and testing the acquired models in integrated design optimization of the marine propulsion system. The model is implemented in MATLAB/Simulink and ANSYS Aqwa and validated using operation data from BC Ferries’ ship Tachek. The modified low-order model (M-LOM) is then used in the integrated optimizations of propulsion system component sizes and operation control strategies for another BC Ferries’ ship, Skeena Queen. The performance, energy efficiency, and emissions of various propulsion options, including diesel-mechanical and diesel-electric benchmarks, and hybrid electric alternatives of series hybrid, parallel hybrid, and battery/pure electric are compared to demonstrate the benefits of the new method in completing these complex tasks and hybrid electric marine propulsion. The research forms the foundation for further studies to achieve more accurate propulsion demand prediction and a more comprehensive lifecycle cost assessment of clean marine propulsion solutions.