University of Victoria | Graduate Studies

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

of

STEFAN KABAN

BSc (University of Victoria, 2010)

"Performance Modeling and Benchmark Analysis of an Advanced 4WD Series-Parallel PHEV Using Dynamic Programming"

Department of Mechanical Engineering

Friday April 10, 2015
12:30 P.M.
Engineering Office Wing
430

Supervisory Committee:
Dr. Zuomin Dong, Department of Mechanical Engineering, University of Victoria (Supervisor)
Dr. Curran Crawford, Department of Mechanical Engineering, UVic (Member)
Dr. Ashoka Bhat, Department of Electrical and Computer Engineering, UVic (Non-Unit Member)

External Examiner:
Dr. Kin Li, Department of Electrical and Computer Engineering, UVic

Chair of Oral Examination:
Dr. Lin Cai, Department of Electrical and Computer Engineering, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

In recent years, concerns have mounted over volatile fuel costs and rising emissions levels. In the transportation sector, increased effort and attention is being put into the development of hybrid vehicles. Hybrid powertrain technology offers a means to reduce fossil fuel consumption by providing multiple on-board energy sources, kinetic energy recovery, and direct displacement of petroleum fuel through vehicle electrification. To fully realize the efficiency benefits of an advanced hybrid architecture, a correspondingly complex supervisory control system must also be implemented to manage it. To better evaluate the performance of these control systems, and to better guide their development, it is necessary to derive operational benchmarks for the vehicle architecture. In this work, a benchmark program is developed in MATLAB to analyse the University of Victoria's EcoCAR 2 competition entry, an advanced series-parallel plug-in hybrid vehicle based on a 2013 Chevrolet Malibu sedan. Benchmark analyses are performed on a low-fidelity MATLAB model using dynamic programming over four standard driving cycles to identify the optimal control actions and resulting fuel consumption in the series and parallel operating regimes. The simulation results indicate a fuel consumption value of 4.91L/100km for the series regime, and 4.74L/100km for the parallel, compared to the stock Malibu's 8.83L/100km. The results are very sensitive to the allowed level of regenerative braking, with consumption values of 6.56L/100km and 6.62L/100km obtained with restricted regen functionality. The parallel regime provided more efficient operation overall, especially during more aggressive driving conditions. However, the series regime provided more desirable operation during gentle driving conditions, where opportunities for regenerative braking are limited. The powertrain control pro-_les generated by dynamic programming were used to drive a higher-fidelity Simulink model. Due to the significant difference between the model structures of the MATLAB and Simulink models, results were not conclusive, indicating that a different approach is required to bridge this gap.