Preface

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Biographical notes: Per Tunestål received his PhD in Mechanical Engineering at the University of California, Berkeley in 2000. He presently holds a position as a Professor at the Lund University where he is in charge of engine control activities. He also serves as the Director of The KCFP Engine Research Center, a consortium financed by The Swedish Energy Agency, Lund University and 14 member companies world-wide. Special interests are engine control based on in-cylinder measurements and cylinder-pressure-based parameter estimation. He holds more than 100 scientific publications and has served as the Chairman of the Control and Calibration Committee within the Society of Automotive Engineers.

Mahdi Shahbakhti is an Associate Professor of Mechanical Engineering at the Michigan Technological University, where he conducts research in the area of controls and energy systems. Prior to joining Michigan Tech in 2012, he was a Post-doctoral Scholar at the University of California-Berkeley. He received his PhD in Mechanical Engineering from the University of Alberta in Canada in 2009. An ASME and SAE member, he has been doing research in the area of powertrains, and controls for the past 17 years. His research centres on developing dynamical models and novel control techniques with application in powertrain and vehicle control. He is the author of over 120 refereed publications in the field of powertrain, energy systems and controls.

Vehicle powertrain has experienced substantial advancement in the past decade through extensive investments by automotive OEMs to reduce CO_2 greenhouse gas emissions from vehicles and meet stringent fuel economy targets such as US CAFE fuel economy standard for light duty vehicles. This has resulted in a broad powertrain portfolio by automotive manufacturers. For instance, the number of hybrid electric vehicle (HEV) models in the USA has increased by over 20 times since 2004 and the total number of vehicle models including conventional, electric, and alternative fuel light duty vehicles

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has over tripled since 2004 (Source: US Alternative Fuels Data Center). Despite the existing large diversity, the major vehicle powertrains for foreseeable future based on market share may include high-efficiency internal combustion engines (ICEs) and different levels of electrification ranging from mild to strong HEVs along with extended range electric vehicles (E-REVs). This special issue includes two research articles that examine the fuel economy benefits of utilising advanced high-efficiency engines in HEV powertrains. One paper investigates the integration of reactivity controlled compression ignition (RCCI) engine in a series hybrid electric powertrain and the other paper investigates the integration of homogeneous charge compression ignition (HCCI) engine for a series hybrid and E-REV powertrain. The analysis results are presented for US06, UDDS, HWFET, and NEDC driving cycles.

Ever-growing complexity in vehicle powertrains has led to a challenging and costly development process for vehicle electronic control units (ECUs). Today's modern vehicles can have more than 100 ECUs with program size of several million lines. The calibration, verification and validation (V&V) cycle of the ECUs for a vehicle powertrain can easily take over two years and cost more than several million dollars. Model-based controller design and verification is a promising way to reduce development and verification time for vehicle powertrains. This will require low-order control-oriented vehicle powertrain models and development of proper techniques for model-based controller design and optimisation. This special issue presents some of the recent efforts on developing novel modelling and control techniques for vehicle powertrain. The application areas include engine combustion control, exhaust emission after treatment control, and energy management of hybrid electric powertrains. The first paper proposes a new control-oriented model for ignition delay in a partially premixed compression ignition (PPCI) engine. The second paper develops an adaptive model-based control technique to reduce vehicular emission during cold start period that requires an integrated control of engine combustion along with control of the exhaust after treatment system. The third paper investigates model-based energy management of a HEV via techniques of model predictive control and dynamic programming.

In addition, three out of four papers in this special issue centre on the application of low temperature combustion (LTC) engines that represent frontiers of the research for high-efficiency ICEs with low emissions. LTC engine technology includes HCCI, RCCI, and PPCI engines that are studied as part of the three research articles in this special issue.

This special issue is dedicated to the memory of Professor J. Karl Hedrick and Professor John J. Moskwa for their outstanding contributions to the engineering community, especially vehicle powertrain and controls. In the following, a brief biography of Professors Hedrick and Moskwa is provided.

J. Karl Hedrick (1944–2017)

Biography[1]: Professor J. Karl Hedrick was best known for the development of nonlinear control theory and its applications to transportation, including powertrain controls, automated highway systems, embedded software design, formation flight of autonomous vehicles, and active suspension systems.

Hedrick received his bachelor's degree in engineering mechanics at the University of Michigan in 1966. He earned his master's and his doctoral degrees in aeronautical and astronautical engineering at Stanford University in 1970 and 1971, respectively.

From 1974 to 1988, Hedrick was a professor of mechanical engineering at the Massachusetts Institute of Technology, where he directed the Vehicle Dynamics Laboratory. He then joined the Department of Mechanical Engineering at the University of California, Berkeley in 1988, where he taught courses in automatic control theory.

While at Berkeley, Hedrick served as the chair of the Department of Mechanical Engineering (1999–2004), and as director of the university's Partners for Advanced Transit and Highways Research Center (1997–2003), which conducts research in advanced vehicle control systems, advanced traffic management and information systems, and the technology leading to an automated highway system. He was also the director of Berkeley's Vehicle Dynamics Laboratory, as well as a co-director of the Hyundai Center of Excellence in Active Safety and Autonomous Systems.

Hedrick was inducted into the United States National Academy of Engineering in 2014. He was a member of the Society of Automotive Engineers (SAE), and the American Institute of Aeronautics and Astronautics (AIAA). In addition, he was a fellow of the American Society of Mechanical Engineers (ASME), and the past chair of the ASME Dynamic Systems and Control Division.

Other honours include the Outstanding Paper Award from the Institute of Electrical and Electronics Engineers, 1998; the American Automatic Control Council's O. Hugo Schuck Best Paper Award, 2003; the ASME Division of Dynamic Systems, Measurement, and Control's Outstanding Investigator Award, 2002; and the ASME Journal of Dynamic Systems, Measurement, and Control Best Paper award in 1983 and 2001. Hedrick received ASME's 2006 Rufus Oldenburger Medal, which recognises significant contributions and outstanding achievements in the field of automatic control. He also delivered the ASME Nyquist Lecture in 2009.

He has written two books and published more than 140 peer-reviewed archival publications. Spanning his career at Arizona State, MIT and Berkeley, Hedrick graduated over 70 PhD students.

John J. Moskwa (1950–2017)

Biography[2]: Professor John J. Moskwa was an international leading expert in the field of powertrain system modelling, diagnosis, and controls. He developed nonlinear engine system diagnostic techniques based on nonlinear observers for engine cylinder heat release and combustion quality identification, as well as pioneer the use of 'synthetic' engine variables to simplify engine diagnostic and control strategy and improve combustion quality diagnostics.

Moskwa received his PhD in Mechanical Engineering from the Massachusetts Institute of Technology (MIT) in 1988, under supervision of Professor J. Karl Hedrick. He received his bachelor and master's degrees in Mechanical Engineering from the University of Michigan-Ann Arbor in 1980 and 1981, respectively.

He joined the Mechanical Engineering Department at the University of Wisconsin-Madison in 1989 and worked until his retirement in 2016. He founded Powertrain Control Research Laboratory (PCRL) at UW-Madison. The PCRL group designed and developed some of the most advanced high bandwidth Hardware-in-the-Loop (H-I-L) engine test systems in the world for transient automotive engine research. Other advanced tools, developed by the PCRL, include highly flexible engine control systems for strategy research, and fast-FID, fast-CLD and other analysers for transient control and emission research.

Dr. Moskwa was a Fellow of the American Society of Mechanical Engineers (ASME), a Fellow of the Society of Automotive Engineers (SAE), and a Senior Member of the Institute of Electrical and Electronic Engineers (IEEE).

He received numerous industry and teaching awards, including the SAE prestigious award for automotive engineering innovation, the Edward N. Cole Award. He was the recipient of the ASME Charles Stark Draper Innovative Practice Award for "his development of high bandwidth transient engine test systems using advanced electronics and hydrostatics that allow engineers to accurately replicate actual dynamic engine and powertrain loads and thereby improve engine powertrain designs". Some of his other honours include Powertrain Excellence Award (1998, 2003) from the International Council for Powertrain Engineering and Management, SAE International Teetor Educational Award (1992), and Polygon Engineering Council Outstanding Instructor Award (1989) at UW-Madison.

Living legacy of Professor Moskwa includes 81 students who graduated from his PCR Laboratory at the University of Wisconsin Madison. These include 16 PhD students, some of them are now professors at different parts of the world.

Notes

1 The biography is based on the materials from http://www.me.berkeley.edu/j-karl-hedrick-professor-nonlinear-control-expert-1944-2017.

2 The biography is based on the materials from https://directory.engr.wisc.edu/me/Faculty/Moskwa_John/, and http://www.cressfuneralservice.com/obituary/185044/John-Moskwa.