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Advances in Mechanical Engineering

Editorial

Advances in Mechanical Engineering
2018, Vol. 10(10) 1–3
© The Author(s) 2018
DOI: 10.1177/1687814018805607
journals.sagepub.com/home/ade
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Advanced powertrain dynamic modelling and control for electrified vehicles

The electrification of the vehicle powertrain has been a continuous research focus in recent years. It brings new challenges while also opportunities to the research of vehicle dynamics and control. Integration of electric machines in the powertrain system can not only modify the structure of vehicle chassis but also change its dynamic characteristics and control system design. Thus, broad research spaces are generated and waiting to be explored in this area. This Special Collection on 'Advanced Powertrain Dynamic Modelling and Control for Electrified Vehicles' is dedicated to recent significant achievements in powertrain system design, modelling, control and optimization for electric vehicles. After strict review procedures, 15 papers among the many submitted manuscripts have been finally published in this Special Collection.

Starting from the propulsion system in the powertrain system, the paper 'Speed robust design of switched reluctance motor for electric vehicle system' presents a new robust controller for switched reluctance motor (SRM) in electric vehicles, which can help the SRM better attenuate the negative effect of external load disturbances as well as system parameter uncertainties by using H-infinity synthesis approaches.[1] In the paper 'Approximate dynamic programming solution for the optimal nitrogen oxides/particulate matter trade-off control of a WAPS engine', a data-driven approximate dynamic programming controller is developed to achieve optimal trade-off between nitrogen oxides and particulate matter emission for a unique 4JB1-Tweifu accumulator pump system (WAPS) engine.[2] In the paper 'Experimental investigation of emission characteristics based on new alcohol-based gasoline fuel', emission characteristics of a new type alcohol-based fuel are investigated in a CA4G5 engine.[3]

The gear system is of great importance to transmission and powertrain systems, and two papers in this area are selected in this Special Collection. In the paper 'Design and analysis of herringbone gear with sixth-order transmission error based on meshing vibration optimization', a dedicated dynamic model of herringbone gear is developed, and a sixth-order transmission error–based meshing optimization approach is proposed to reduce the gear transmission vibration and noise.[4] Similarly, by using an improved Load Tooth Contact Analysis (LTCA) model, the influence of pitch deviation on the gear meshing stiffness and vibration noise for cylindrical helical gear is investigated in the paper 'Study of the influence mechanism of pitch deviation on cylindrical helical gear meshing stiffness and vibration noise'.[5] For the transmission system, the paper 'Analysis of multi-speed transmission and electrically continuous variable transmission using lever analogy method for speed ratio determination' presents an improved lever analogy method to analyse multi-speed planetary gear sets for speed ratio determination, and performance of the proposed method is demonstrated by using a multi-mode electric variable transmission (EVT) in hybrid powertrain system.[6]

Recently, multi-speed transmission design for pure electric vehicles has attracted increasing research effort due to its promising effect in efficiency improvement and torque range extension. Therefore, three related papers are selected in this Special Collection. In the first paper 'Development of continuously variable transmission and multi-speed dual-clutch transmission for pure electric vehicle', a comparative study is presented to investigate the performance of pure electric vehicle using multi-speed dual-clutch transmission (DCT), continuously variable transmission (CVT) and single reduction gear.[7] Another paper titled 'Multi-stage global trajectory optimization for the overlapping shift of a seamless two-speed transmission using Legendre pseudo-spectral method' presents a seamless two-speed transmission for pure electric vehicles, and a Legendre pseudo-spectral method is proposed to transfer the trajectory optimization problem in both torque phase and inertia phase into a nonlinear programming problem, by which the overall overlapping shift process can be better considered.[8] The third paper 'Design, analysis, and experimental validation of a novel seamless automatic transmission for electric vehicle' proposes a two-stage epicyclical gear sets based on two-speed automatic transmission for pure electric vehicles, and multi-

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island genetic algorithm is adopted to gear ratio optimization problem to improve dynamic performance and reduce power consumption simultaneously.[9]

Finally, for research on electrified powertrain as well as whole vehicle systems, five related papers are selected in this Special Collection. In the paper 'Torque coordinated control in engine starting process for a single-motor hybrid electric vehicle', a coordinated clutch pressure, motor torque and engine torque control strategy is proposed for parallel hybrid electric vehicles to tackle the excessive torque ripple problem during engine starting process.[10] Similarly, the paper 'Traction control–integrated energy management strategy for all-wheel-drive plug-in hybrid electric vehicle' presents an integrated engine throttle, motor torque and active braking control strategy for an all-wheel-drive plug-in hybrid electric vehicle, which improves the hybrid vehicle's traction control performance and fuel efficiency.[11] Considering the influence of temperature variation, the paper 'Research on energy management of hybrid energy storage system for electric bus' presents a convex optimization–based energy management approach for a semi-active hybrid energy storage system in electric bus, by which minimum energy consumption, and maximum discharge as well as charge depth of super capacitor, can be simultaneously achieved.[12] The paper 'Study on stability and handling characteristics and control of four-wheel-drive electric vehicles' investigates the stability and handling performance of four-wheel-drive electric vehicles by using co-simulation studies with Simulink and CarSim. Based on the co-simulation model, a proportion-integral-derivative controller is further developed to better adjust the torque distribution between front and rear wheels, while a sliding mode controller is designed to optimize the left–right torque distribution.[13] Also for four-wheel-drive electric vehicles, the paper 'Analysis and optimization of energy efficiency for an electric vehicle with four independent drive in-wheel motors' proposes an optimal torque allocation approach to achieve energy efficiency improvement. The dynamic model and efficacy maps of the in-wheel motors are established by using real experimental data from bench tests as well as chassis dynamometer tests, and the optimal torque distribution between front and rear axles is guaranteed by using a novel control scheme.[14] Apart from the research of ground vehicles, one paper titled 'Path planning for underwater glider under control constraint' introduces a novel optimal three-dimensional path planning method for underwater vehicles, for example, an underwater glider, and is also selected in this Special Collection. The proposed path planning method is derived by using Pontryagin's minimum principle, which can result in a lower rate of energy consumption compared with traditional three-dimensional Dubins path.[15]

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Acknowledgements

We would like to express our thanks to the authors in the field for their submissions, to the reviewers for helping the authors improve the quality of their manuscripts and to the editorial office for their valuable time and effort spent co-organizing this Special Collection.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported in part by the National Natural Science Foundation of China (under Grants 51605278 and 51505276).

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