Guest Editorial Introduction to the Special Section on More Electric Vehicles

IN ORDER to face the energy transition challenge, the transport sector should electrify more and more vehicles. The 2016 transport report of the International Energy Agency indicated that, from several scenarios, the number of electrified road vehicles has to move from 1 Million to 100 Millions in only 15 years to keep the global warming under +2 °C. The electrified vehicles can be classified in pure Electric Vehicle (EV, supplied by a battery but also by the electrical grid), Hybrid Electric Vehicle (HEV, combination of electric motors and thermal engine), and Fuel Cell Vehicle (FCV, with H_2 as energy source). These disruptive technologies thus require fast development to face this challenge.

IEEE Vehicle Power and Propulsion Conference (VPPC) is an annual conference of the IEEE Vehicular Technology Society (VTS). The 16th IEEE-VPPC was held in Hanoi, Vietnam, in October 2019. There were 265 papers submitted and 212 papers accepted and presented at the conference. In order to further promote research excellence in vehicle power and propulsion, in collaboration with the 2019 IEEE VPPC organizing committee and the VPP technical committee, a special section of the IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY has been organized to focus on the development of more electric vehicles. The TVT special section is focused on the system level while a special section in *IET Electric Systems for Transportation* is focused on the component level.

The papers submitted to this Special Section had to offer substantial novel contributions beyond the previous work presented in the conference paper (substantial change more than 50%). Papers co-authored by the Guest Editors of this Special Section cannot be accepted in this special section. The submissions have been first checked by the Editor-in-Chief and it should be highlighted that some submissions have been directly rejected due to a high similarity index. This automatic process can be considered as questionable by the authors, but they should know that if the conference paper can have only 30% of similarity, other similarity can be found in other papers and the final result will be the cumulative similarity index. As this process is growing in any high-quality international journal, they are encouraged to take sufficient margin to avoid this issue. Then 24 submissions were transmitted to the Guest Editors. Each paper was associated with a Guest Editor from a different country than the author's country. After the reviewing process that includes a unique possible revision, six papers were accepted for publication (25% of acceptation rate).

The two first papers are dedicated to the battery of EV, which is the most sensitive element in such vehicles. This first paper is dedicated to a battery design procedure for high power vehicle as a race electric motorbike. The second paper deals with an optimal charging strategy of batteries with a compromise between charging time and temperature rise for avoiding fats battery ageing.

- "Sizing of A Battery Pack Based on Series/Parallel Configurations as a Constrained Optimization Problem for High-Power Electric Vehicle", by Louis Pelletier, Félix-Antoine LeBel, Carlos Henggeler Antunes and João Pedro F. Trovão.

The design of electric vehicle batteries is a challenge requiring significant computational, human and material resources. This paper proposes a new framework to design a battery pack that allows quick iterations between designs and computes optimized configurations to give more information about the best available solutions. The battery pack is represented as a series/parallel configuration in a Constraint Satisfaction Problem (CSP) that is solved to exploit every possible configuration for specific vehicle requirements. The result is then used in a multi-objective Constrained Optimization Problem (COP) to determine the non-dominated (Pareto optimal) solutions according to selected objectives functions. Non-dominated solutions are computed by optimizing weighted-sum scalar functions as well as minimizing different types of distances to a design reference. A case study is explored to design a battery pack for an electric motorcycle. A 24s/6p battery module designed with this methodology has been validated by experiments and the battery pack has successfully been used at MotoStudent in 2018.

- "Research on Optimization of Charging Strategy Control for Aged Batteries" by Sun Jinlei, Ma Qian, Tang Chuanyu, Wang Tianru, Jiang Tao and Tang Yong.

Rapid charging of lithium-ion batteries has become a major bottleneck for the large-scale deployment of electric vehicles. In this paper, a charging optimization method is proposed for lithium ion batteries based on their aging characteristic, which takes charging time and temperature rise into consideration. An electric-thermal battery model is utilized to estimate the battery temperature during charging. A search for the optimal charging current pattern is performed using a particle swarm optimization (PSO) algorithm combined with fuzzy reasoning. The experiments are conducted on batteries with different aging states

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to verify the proposed method. Besides, the proposed method is compared with traditional constant current-constant voltage (CC-CV) charging method. Results show that the proposed charging strategy has advantages on maximum temperature rise maintenance and charging speed improvement for aged batteries with unknown aging state. The proposed charging method provides a way for charging of aged batteries considering charging time and temperature rise.

The following two papers are focused on the temperature effects during the vehicle operation. The third paper proposes a self-heating method of a fuel cell systems for cold-start of a fuel-cell vehicle. The fourth paper deals with an optimal thermal management of the battery during driving cycles of an EV to limit the ageing effect.

- "An Online Proton Exchange Membrane Fuel Cell Self Cold Startup Methodology for Hybrid Electric Vehicle Applications" by A. Amamou, M. Kandidayeni, S. Kelouwani and L. Boulon.

This paper puts forward an adaptive cold start strategy for a proton exchange membrane fuel cell (PEMFC) based on maximum power mode. The proposed strategy consists of a water evacuation process after PEMFC shutdown and a self-heating process at PEMFC cold startup. To maximize the performance of the suggested strategy, an optimal operating condition for the cold start procedure is sought first. In this respect, an experimental parametric study is performed to explore the impact of fan velocity, micro-short circuit, anode pressure, and purge procedure on the PEMFC cold start performance. After laying down the proper conditions, the proposed cold start procedure is implemented on a test bench for experimental validations. The self-heating process is based on an online adaptive algorithm that maximizes the PEMFC's internal heat depending on its operating parameters' variation. In fact, this algorithm attempts to keep the current density at high levels, leading to PEMFC's performance improvement achieved by membrane hydration and temperature increase. The experimental results confirm the effectiveness of the proposed strategy, which presents a fast and cost-effective PEMFC's cold start.

- "Computationally Efficient Stochastic Model Predictive Controller for Battery Thermal Management of Electric Vehicle" by Seho Park and Changsun Ahn (already published in vol. 60, issue 8, pp. 8407–8419)

The performance and safety of batteries of electric vehicles deteriorate when the battery temperature is too low or too high. The thermal management system regulating the battery temperature consumes considerable electric energy, particularly, for cooling the battery. To maximize the vehicle driving range, the means of controlling the battery temperature should minimize the energy consumption. In this paper, stochastic model predictive control is applied to the battery-cooling controller. Effective model predictive control requires a good but simple system model with proper estimation of near-future disturbances. The components of the battery cooling system are modeled to represent the energy-consumption and heat exchange mechanism with some assumptions for simplicity. The future information is estimated using historical driving data in a stochastic sense. For real-time implementation, an unequally spaced probability distribution is introduced when designing a stochastic model of future heat generation. The proposed control method shows significantly lower energy consumption while maintaining an acceptable temperature regulation performance compared to other temperature controllers, such as a thermostat-type controller and a model predictive controller with simply assumed future information. The proposed predictive controller shows robust performance compared to typical controllers by utilizing the stochastic estimation of future information.

The two last papers are eco-driving of two different kinds of vehicle. This fifth paper discusses eco-driving an electric vehicle by considering traffic information and road condition. The sixth paper deals with the impact of the energy consumption of a subway on the supply system, and specifically of an eco-driving mode.

- "Energy-Optimal Adaptive Cruise Control for Electric Vehicles based on Linear and Nonlinear Model Predictive Control" by Yanzhao Jia, Rabee Jibrin and Daniel Goerges.

This paper presents a novel function of energy optimal adaptive cruise control (EACC) for electric vehicles based on model predictive control (MPC), which plans the host car.s speed trajectory in real time for higher energy efficiency by taking look-ahead traffic information and road conditions into consideration. After a time domain Linear MPC (LMPC) formulation, a space domain Nonlinear MPC (NMPC) formulation is proposed to counter the limitations of the time domain LMPC. To coper with computational complexity of NMPC in space domain, the nonlinear equality constraints are relaxed to inequality constraints to yield a convex optimization problem. Moreover, it is proven that the relaxed optimization problem can be recast as a second-order cone programming (SOCP) problem, for which the efficient numerical optimizers exist. The performance of NMPC is evaluated using simulation against the time domain LMPC and a theoretically optimal receding horizon dynamic programming (RH-DP) solution. Results indicate that the proposed space domain NMPC outperforms LMPC in time domain and has nearly the same performance as RH-DP.

- Impact of Railway Energy Efficiency on the Primary Distribution Power Grid, by Marilisa Botte, Luca D'Acierno, and Mario Pagano.

Electrified railway systems are the current focus of energy efficiency studies due to the increasing constraints of environmental sustainability policies. Railway System Operators (RSOs), also encouraged by market deregulation, are thus examining how to update infrastructures and vehicles and/or apply new operating strategies. Given the intrinsic relation between railway systems and their primary feeding grid, each measure applied to a railway system impacts directly on the power grid which supplies the system. Against this background, this paper aims to ascertain the impact of an energy efficiency strategy applied by the RSO system on its primary grid. The energy-efficient strategy is identified as to preserve timetable stability and service quality in a passenger-oriented perspective. Moreover, a method to model the interaction between the systems in terms of power flow exchanges is proposed. The model is used to verify how an eco-driving technique applied to a metro system affects the state variables of the distribution grid. In particular, the primary

grid, the traction power substations and the railway system are modelled according to real data. The case study is the Metro Line 1 operating in the city of Naples (Italy). The numerical simulations are carried out with a two-step procedure: first, the power requirements of the rolling stock as a function of the imposed operating service are calculated by OPENTRACK software; the state variables of the distribution grid are then evaluated by means of the power flow approach.

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