Editorial

Current Progress in Automobile Design and Manufacturing

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Received: 26 December 2022
Accepted: 26 December 2022
Published: 27 December 2022

On behalf of the editors, I am delighted to introduce the *International Journal of Automotive Manufacturing and Materials*'s inauguration as "Current Progress in Automobile Design and Manufacturing" with an emphasis on the application of the state-of-the-art technology in automotive industry. Our enthusiasm for this inaugural issue stemmed from the unprecedented opportunity today to develop novel methods for energy utilization and environmental protection. The progresses have converged to offer a unique era for us to focus our mindpower on developing new technologies. Automotive engineering exemplifies "big avenue," because it requires an integrated and effective pipeline executing from academia, industry, and regulatory agencies to identify, to evaluate, to develop, to approve new forms of material, energy utilization, and control system. In this context, we collate 10 inspiring and well-prepared articles to appraise valuable and timely information in key aspects of the current automobiles.

Guan and Dai (FREng, IEEE Fellow, ASME Fellow, RSA Fellow, IMechE Fellow, King's College London) et al. [1] denote that the reconfigurable intelligent manufacturing factory of automobiles is developing and focusing on reconfigurability in structure, manufacturing and algorithms, thus advancing the level of reconfigurable intelligent manufacturing continuously. With sufficient reconfigurable manufacturing technology as the basis, reconfigurability can be better introduced into the structure design and driving algorithm of automobiles. Reconfigurability will provide a new bridge for transformation of the traditional automobile to reconfigurable automobile, and a new driving force for the promotion and upgrading of reconfigurable driving algorithm.

Industry 4.0 is shaping the metal forming industry. The ongoing key Industry 4.0 technologies, including the industrial cyber-physical system, industrial internet of things, digital twin, big data, and cloud computing, are expected to improve every stage of metal forming processes, covering the supply chains, raw material provision, tool design and manufacture, forming operations, energy consumption, cost reduction, quality control, and customer services. Based on the discussion of the opportunities and challenges of Industry 4.0 technologies in metal forming, Liu and Wang et al. [2] from Imperial College London provided some perspectives of future metal forming research directions towards automotive applications.

Lightweight materials are highly demanded in electric vehicles to reduce environmental impacts and energy consumption. Aluminium alloys are promising materials in electric vehicles due to their advantages such as high specific strength, corrosion resistance and recyclability. However, forming complex-shaped thin-wall aluminium products is challenging due to their poor formability and dimensional accuracy. Also, recycling some of the high-strength aluminium alloys from electric vehicles is still challenging. Zhou et al. [3] from NTNU of Norway highlighted some of the future potential aluminium forming techniques for electric vehicle production, including the incremental sheet forming, hot forming and quenching technique, and transverse stretching and local bending. Also, the issues associated with aluminium recycling were listed and discussed. Their review provided scientific guidance to the industry and the scientific community for advancing the applications of aluminium alloys in electric vehicles.

Wang et al. [4] studied and analyzed the motion planning method of intelligent connected vehicles. They proposed a two-degree-of-freedom model combined with the tire model in their study. At the same time, a turning control model is analyzed, which lays the foundation for the subsequent local path planning, that is, the simulation control of lane changing and obstacle avoidance. The co-simulation of software of CarSim and

Simulink is used to realize the tracking control of trajectories, and the given reference trajectory can be tracked with high precision in the serpentine rod penetration test, so as to verify the stability of the control algorithm control. A set of optimal trajectories of straight lane change and curved lane change are selected as the reference trajectories of the controller, and the target speed of the lane change is given in the CarSim speed control module. The simulation results show that the motion planning error is extremely small that completes the high-precision automatic control of steering, and this helps realize the tracking of a given trajectory, reflecting the good trackability of the planned lane-changing trajectory from the side. Aiming at the automatic lane changing process of the intelligent connected vehicle on different straight roads and curved roads, the vehicle-to-vehicle communication is used to obtain the status information of the surrounding traffic vehicles where the multi-objective optimization method is used to determine the optimal trajectory. Driving with reference to the trajectory realizes the coordination and unity of planning and control.

The technology of hydrogen fuel cell vehicles is the ultimate direction of clean energy vehicle development, and commercial vehicles are the most important application area for fuel cell commercialization. Ren et al. [5] from Dongfeng Commercial Vehicle Company reviewed the fuel cell system technology from fuel cell stack to system integration. They summarized the key components, technologies and development trends of the fuel cell stack, fuel cell system and vehicle integration in different countries, and pointed out that key materials (i. e., bipolar plates and membrane electrodes), key system components (i. e., air compressors and ejectors), high-power modular integration technologies, and fuel cell control technologies are the main factors influencing the commercialization of fuel cell vehicles. Particularly, they focused on variable ejector or multi-stage ejector technology, integrated and optimized control technology, and multi-energy cooperative control technology due to their crucial roles in meeting the industrial development of fuel cell vehicles. Some guidance opinions were also provided for reference about the development and industrialization of fuel cell vehicles.

Decarbonization requires global actions, and the transport sector is the main battlefield since it contributes more than 20% of carbon dioxide emissions. Vehicle electrification is an effective routine to reduce vehicle carbon emissions, but it increases the complexity of the vehicle systems, especially the powertrain systems. The rapid development of artificial intelligence is promoting the development of new automation technologies that can benefit the automotive industry. Zhou et al. [6] from University of Birmingham reviewed artificial intelligence and its roles in the research and development of vehicle powertrain products, focusing on the key milestones of AI technology progress for vehicle research and development, and the advantage of AI-based methods in powertrain design and control. They also provided an outlook toward future research directions.

Hydrogen energy is regarded as the best form to achieve the dual-carbon strategic goal of "carbon peaking and carbon neutrality". It is well-known that hydrogen energy has the characteristics of zero carbon, green, high energy, and renewable. Recently, the pure hydrogen internal combustion engine (PH-ICE) has become one of the essential directions of hydrogen energy application due to its outstanding advantages, such as no carbon emissions, high efficiency, high reliability, and low pollution. So far, the PH-ICE has aroused great attention from many automotive companies and research institutions. Lu and Liu et al. [7] highlighted the latest development status of the PH-ICE. A comprehensive summary of the combustion performance improvement and nitrogen oxide control technology of the PH-ICE was provided, from the in-engine and out-engine technologies. The future challenges and development trends of the hydrogen ICE were discussed.

The primary breakup in the diesel spray relies closely on the initial dynamics at the nozzle exit. Solid experimental results are still missing due to the great difficulties in the measurement of the near-nozzle spray dynamics. Gao and Huang et al. [8] from Argonne National Laboratory of United States investigated transient nozzle-exit velocity profile in diesel spray and its influencing parameters. In their study, an investigation was proposed focusing on the transient nozzle-exit spray dynamics by taking advantage of the X-ray phase contrast imaging technique. The in-nozzle needle motion, spray morphology, and dynamics at the nozzle exit of a commercial diesel nozzle were obtained. Experimental results were then examined linking with the needle motion to understand the transient spray dynamics. The effect of the initial conditions on the resulting trends were also considered. It is found that the nozzle-exit spray morphology and velocity profile highly relate to the in-nozzle needle lift. Once the needle sufficiently opens, the spray reaches steady status and the nozzle-exit velocity becomes almost constant. The spray width slightly increases with the increasing ambient gas density or the decreasing injection pressure. Injection pressure has a significant effect on the spray velocity amplitude, whereas the ambient gas density alters the spray-velocity profiles mainly in the periphery of the spray. They conducted an analytic analysis to further examine the transient spray axial velocity with the changing radial locations. It is found the nozzle-exit spray velocity can be predicted in the Gaussian type of formula. This feature likely relates to in-nozzle flow characteristics.

Exhaust gases released from vehicle engines have been a major cause of air pollution, and the emission limits have become much stricter in recent years due to a worldwide concern about the impact of air pollution on public health. These regulations have been complied to minimize the emissions of carbon monoxide, hydrocarbons, nitrogen oxides, and particulate matter from gasoline and diesel vehicles engines. Different after-treatment systems have been developed for the treatment of exhaust gases from gasoline and diesel engines, respectively. Bao and Chen et al. [9] from Nankai University reviewed exhaust gas after-treatment systems for gasoline and diesel vehicles, and summarized the after-treatment systems for gasoline engine based on the three-way catalysts, and for diesel engines based on the diesel oxidation catalysts, selective catalytic reduction, diesel particulate filters, and ammonia slip catalysts.

A key area to assist with fuel consumption and emissions reduction targets in automotive industry is the implementation of renewable energy combined with energy storage technologies. The renewable energy generation methods are solar, wind, and hydroelectric power. These low-carbon resources are deemed as the most influential based on their significant contribution to the global energy mix and their greater annual power capacity compared to other renewables. Although energy generation is essential, the ability to store this energy is critical to the success of a renewable economy. At present, efficient energy storage presents numerous challenges and effective energy storage solutions are critical to further penetration of renewable assets such as solar and wind. It is anticipated that increasing flexibility of supply through storage will increase utilization of renewable power. This would facilitate a cost-effective transition away from fossil fuels by automotive applications. Yu and Wang et al. [10] from Imperial College London reviewed various means of production for renewable energy and energy storage technologies with the specific focus on the automotive industry. In their review, centralized energy storage technologies—specifically lithium-ion batteries are discussed since they are the most widely used battery storage technology found in electric vehicles. Moreover, demand for lithium-ion batteries is expected to increase exponentially as the electric vehicle market expands. As an ideal alternative, distributed energy storage realized by embodied energy storage technology is also discussed. Although distributed energy storage technologies remain mostly in the research phase, they offer great potential to enable volume and mass savings, thus enhancing the efficiency and range of electric vehicles in the future.

In closing, the collection of review and research articles in this themed issue illustrates a holistic picture of recent progress in automotive engineering following a logical manner. They show the diverse and inspiring strategies for identifying environmental protection targets, repurposing manufacturing, and tooling novel materials. Importantly, they also highlight the still unmet challenges and drawbacks that could be addressed by combining disciplines and working interactively. The stage is now set for the translation of these discoveries into new technologies that will affect many forms of vehicles. The editors hope the information presented in this issue will be useful not only to scholars but also to a general readership with an interest in learning automotive manufacturing across academia, industry, regulatory agencies for energy utilization and environmental protection. Finally, the editors thank the authors and reviewers for their overall enthusiasm and enormous efforts in enabling this inaugural issue to cover such a wide range of contemplations for this rapidly evolving field.

Conflicts of Interest: The authors declare no conflict of interest.

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Citation: Liu, Z. Current Progress in Automobile Design and Manufacturing. *International Journal of Automotive Manufacturing and Materials* **2022**, *1*, 11.

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