Advances in Automobile Engineering

Extended Abstract

Intelligent Hydrogen Fuel Cell Range Extender for Battery Electric Vehicles

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Abstract

Road transport is recognized as having a negative impact on the environment. Policy has focused on replacement of the internal combustion engine (ICE) with less polluting forms of technology, including battery electric and fuel cell electric powertrains. However, progress is slow and both battery and fuel cell based vehicles face considerable commercialization challenges. To understand these challenges, a review of current electric battery and fuel cell electric technologies is presented. Based on this review, this paper proposes a battery electric vehicle (BEV) where components are sized to take into account the majority of user requirements, with the remainder catered for by a trailer-based demountable intelligent fuel cell range extender. The proposed design can extend the range by more than 50% for small BEVs and 25% for large BEVs (the extended range of vehicles over 250 miles), reducing cost and increasing efficiency for the BEV. It enables BEV manufacturers to design their vehicle battery for the most common journeys, decreases charging time to provide convenience and flexibility to the drivers. Adopting a rent and drop business model reduces the demand on the raw materials, bridging the gap in the amount of charging (refueling) stations, and extending the lifespan for the battery pack. Environmental and legislational demands associated with the reduction of greenhouse gases (GHG) is encouraging the automotive industry to move from internal combustion engine (ICE) propulsion to zero tailpipe emission (ZTE) systems. Battery electric and hydrogen fuel cell (FC) technologies have been recognized as having the most potential for automotive ZTE systems [1,2,3]. The remaining challenges preventing wider commercial adoption of battery electric vehicles (BEVs) include the insufficient range, dependency on charging infrastructure, overall vehicle efficiency, limited raw materials and recycling. Additionally, fuel cell electric vehicle (FCEV) challenges include hydrogen fueling infrastructures, vehicle cost and vehicle design to reduce risks associated with accidents.

The current solutions for extending the range of BEVs include increasing battery size and hybridizing other propulsions to the BEV, such as range extending electric vehicles (REEVs) based on petrol engine (PHEV) or fuel cell systems (FCEV). The aim of this paper is twofold. First, to review the current challenges and opportunities associated with ZTE, and second, to exploit the review to justify the design of a novel demountable intelligent hydrogen fuel cell range extender for BEVs. The remainder of this paper is organized as follows. Section 2 reviews the environmental and political background of the low carbon vehicles (LCVs) with a focus on ZTE vehicle technologies. Section 3 and Section 4 will discuss the current status of BEVs and FCEVs to demonstrate their advantages over internal combustion engine vehicles (ICEVs) and other alternative technologies. Section 5 will introduce the intelligent demountable hybridization method between the BEV and hydrogen fuel cell technology for passenger vehicles to maximize the advantages of both BEVs and FCEVs and minimize current challenges of the two technologies and bridge the gaps of speeding replacements in ICEVs. Based on the challenges of current BEVs and FCEVs, the paper will discuss the potential of the intelligent demountable hydrogen fuel cell range extender for BEVs to solve the problems, improve the efficiency and reduce costs for BEV. There is currently a political and ideological desire to move from internal combustion engines to electric vehicles, to reduce emissions and therefore pollution at the point of use. The current challenges to realizing this goal include the race to larger battery packs, resource and raw material potential shortages, battery technology limitations and limited infrastructure to support a large fleet of BEVs. There is therefore a gap between the political will and achievable BEV fleet increases. This paper has proposed a new trailer-based intelligent fuel cell range extender to bridge this gap. The applicability, effectiveness and efficiency of the solution has been justified based on a review of the current issues and solutions associated with the range limitations suffered by battery operated vehicles (BEVs). The proposed 1.8 kg

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fuel cell tank can extend the range of small and large BEVs by more than 50% and 25%, respectively, to achieve ranges between 250 and 350 km. The trailer-based demountable design reduces dependency on charging infrastructure and increases refueling station utilization efficiently by centralization refueling. The ability to add range extension on demand enables manufacturers to reduce battery pack sizes for BEVs, helping reduce the pressure on raw materials and need for recycling. Designing a BEV for the most common journeys, in contrast to designing for maximum expected range, reduces the overall cost and increases BEV efficiency. It provides additional usability, due to the flexibility to rent this range extender for occasional long-distance journeys. The ability to recharge or maintain the battery charge within conservative SoC limits can help maintain battery health and minimize the detrimental impacts of external environmental conditions. In addition to the aforementioned benefits to BEVs, the proposed approach can also benefit FCEVs. It can, in the short term, rationalize infrastructure development, hydrogen production, distribution and reduce cost. This intelligent fuel cell range extender could support the development of BEVs and FCEVs for zero TTW emissions and bridge the gap between current and future automotive market demands.

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