Advances in Automobile Engineering

Extended Abstract

Hybrid Electric Powertrain with Fuel Cells for a Series Vehicle

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Abstract

Recent environmental and climate change issues make it imperative to persistently approach research into the development of technologies designed to ensure the sustainability of global mobility. At the European Union level, the transport sector is responsible for approximately 28% of greenhouse gas emissions, and 84% of them are associated with road transport. One of the most effective ways to enhance the de-carbonization process of the transport sector is through the promotion of electric propulsion, which involves overcoming barriers related to reduced driving autonomy and the long time required to recharge the batteries. This paper develops and implements a method meant to increase the autonomy and reduce the battery charging time of an electric car to comparable levels of an internal combustion engine vehicle. By doing so, the cost of such vehicles is the only remaining significant barrier in the way of a mass spread of electric propulsion. The chosen method is to hybridize the electric powertrain by using an additional source of fuel; hydrogen gas stored in pressurized cylinders is converted, in situ, into electrical energy by means of a proton exchange membrane fuel cell. The power generated on board can then be used, under the command of a dedicated management system, for battery charging, leading to an increase in the vehicle's autonomy. Modeling and simulation results served to easily adjust the size of the fuel cell hybrid electric powertrain. After optimization, an actual fuel cell was built and implemented on a vehicle that used the body of a Jeep Wrangler, from which the thermal engine, associated subassemblies, and gearbox were removed. Once completed, the vehicle was tested in traffic conditions and its functional performance was established.

With climate change becoming of increasing concern in recent years, vast global efforts have focused on producing renewable energy sources and reducing greenhouse gas emissions . In addition to energy production, the transport sector has been a major focus of such efforts due to the vast amount of emissions from vehicles. In the European Union, for example, the transport sector is responsible for approximately 28% of greenhouse gas emission, of which 84% are associated with road vehicles. Due to this, there has been a huge industrial drive to develop low emission, electric alternatives to standard combustion engine vehicles.

Fully electric vehicles have many obvious advantages, including the absence of pollution associated with internal combustion (greenhouse gases, other gaseous and particulate pollutants, noise), lower refueling costs, and lower maintenance costs. Despite these advantages, there remain several major disadvantages to electric vehicles: reduced driving autonomy, long battery charging time, and increased cost. Further development of the electric car market is largely dependent on solutions which minimize these disadvantages. For this reason, sustained efforts are being made in research and development to obtain products and technologies to help overcome these problems and promote the use of electric vehicles.

One suggested solution to mitigate the problems described above is to develop hybrid vehicles which can reduce the time between two successive refueling events. The implementation of a second energy storage vector on a vehicle, which can allow the battery to charge during movement, will increase the time span between successive refueling and also improve travel autonomy. One such hybrid system is the tandem hydrogen and proton-exchange membrane fuel cell. The hydrogen-based fuel cell has proven its effectiveness in storing and converting chemical energy directly into electricity, and possesses several advantages: The main reaction product is water. Hence, energy production does not directly generate CO2 emissions and does not pollute, provided that the fuel hydrogen is produced using renewable energy sources. Such fuel cell systems have a high efficiency, between 40% and 45% for complete systems including the electrical power consumed by ancillary equipment.

Due to such benefits, the world's leading manufacturers in the automotive industry have included the problem of implementing hydrogen and fuel-cell-based technologies on their agenda.

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The optimization and implementation of hydrogen-based fuel cells for electric vehicles requires further and more in-depth research, despite the dedicated efforts that have been carried out so far. In this manuscript, we design a proton exchange membrane fuel cell (PEMFC) to hybridize the electric powertrain of a vehicle. By implementing simulations of a vehicle's performance, we optimized the design of the fuel cell system. Inspired by the simulation results, a real fuel cell was created and implemented in a modified Jeep Wrangler. The resulting vehicle was tested under standard traffic conditions. This paper presents the results of this study, which was initiated in 2009 at the Hydrogen and Fuel Cells Center of National Research and Development Institute for Cryogenic and Isotopic Technologies—ICSI Rm. Valcea.

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