

Recent Advances in the Development of Hyundai · Kia's Fuel Cell Electric Vehicles

2010-01-1089

Published
04/12/2010

Woosuk Sung, Yo-In Song, Ki-Ho Yu and Tae-Won Lim
Hyundai Motor Company

Copyright © 2010 SAE International

ABSTRACT

Wide attention to fuel cell electric vehicles (FCEVs) comes from two huge issues currently the world is facing with: the concern of the petroleum reserves depletion due to consequent oil dependence and the earth global warming due in some extent to vehicle emissions. In this background, Hyundai, along with its sister company Kia, has been building the FCEVs and operating their test fleet with several tens of units at home and abroad. Since 2004, 32 passenger vehicles have been offered for the Department of Energy's controlled hydrogen fleet and infrastructure demonstration and validation project in the U.S. In the mean time, from 2006, 30 passenger vehicles as well as four buses, featuring the in-house developed fuel cell stack and its associated components, are currently under the domestic operation for the FCEV learning demonstration led by the Ministry of Knowledge and Economy. Based on such opportunities for developing and demonstrating FCEVs, a great deal of technical progress has been made in many fields, resulting in the performance comparable to the conventional vehicles. The Hyundai Tucson FCEV is powered by the in-house developed 100 kW-fuel cell stack, offering a ultra-high fuel economy of 72 mpg city and a rapid cold-start and drive capability taking on the order of ten seconds at sub-zero temperatures as low as -20°C . Meanwhile, the Kia Borrego FCEV is equipped with the outsized 115 kW-fuel cell stack fueled with the hydrogen compressed at 700 bar, giving a practical range of over 450 miles which has been demonstrated by the single-fueling cruising from San Francisco to Los Angeles in California by virtue of a best-in-class system efficiency of 62 percent and an onboard hydrogen storage of 7.9 kg. This paper updates the recent advances in the Hyundai-Kia's FCEV research and development, especially focusing on the advance of the vehicle performances: cruising range and cold start and drive capability.

INTRODUCTION

Hyundai has recently launched an environmental initiative named Blue Drive which will produce a family of eco-friendly vehicles and establish Hyundai as an environmental leader along with its sister company Kia, underscoring their global commitment to sustainable mobility. With Blue Drive technologies, Hyundai plans to lead all automakers in the U.S. market in fuel economy by attaining a fleet average of 35 miles per gallon (mpg) by 2015, five years ahead of the National Highway Traffic Safety Administration's (NHTSA) deadline. Near term, Hyundai will begin to build a full hybrid edition of the next-generation Sonata for the U.S. market following the mild type hybrid based on the Elantra sold initially in the Korean domestic market from 2009. Long term, the Hyundai Blue Drive family will be expanded to include plug-in hybrid electric vehicles, battery electric vehicles as well as fuel cell electric vehicles (FCEVs).

Among such a wide array of eco-friendly technologies for a next generation vehicle, a fuel cell has drawn wide attention as a promising power source that can ultimately resolve two huge issues the world is facing with: the concern of the petroleum reserves depletion due to consequent oil dependence and the earth global warming due in some extent to vehicle emissions. A fuel cell is an electrochemical device that converts chemical energy into electrical energy. In terms of such energy conversion, fuel cells may look similar to batteries and combustion engines that are used to generate electrical energy. But unlike batteries, fuel cells can produce electricity as long as they are supplied with a fuel. Besides, in contrast to combustion engines, fuel cells can produce electricity directly from electrochemical reactions without multiple energy conversions including heat and mechanical motions. Continuous operation, zero emission, and great efficiency can therefore be realized in fuel cells which are envisioned as a power source for a next generation vehicle [1]. Being motivated by such benefit of a fuel cell, many



Documents

Document Sharing Hub

Fuel cell alliances have been formed to research and develop a fuel cell powered vehicle among auto manufacturers, energy providers, government agencies, and fuel cell companies. Since 2000, Hyundai in company with Kia have been also building FCEVs and conducting public road tests at home and abroad [2,3].

Despite of such efforts to expedite the commercialization of FCEVs, there are still many issues to be addressed. For their operational readiness under actual automotive environments, FCEVs need to be able to function over a full range of ambient conditions and also range as far as existing conventional vehicles. In addition, fuel cell systems employed in FCEVs are required to be as durable as current internal combustion engines (ICEs). Furthermore, fuel cell systems must be reduced in cost and complexity for the fuel cell technology to be accepted as a future automotive power source. Among these issues, the advance of the vehicle performances, cruising range as well as cold start and drive capability, is outlined in this paper.

PROGRESS OF FCEV DEVELOPMENTS IN HYUNDAI · KIA

BRIEF HISTORY

In 2005, Hyundai and Kia opened their eco-technology research institute in Mabuk, Korea, which houses companies' research and development activities to build future alternative powertrains including a hydrogen-powered fuel cell stack and its associated components. In the U.S., Hyundai has been a member of the California Fuel Cell Partnership (CaFCP) since 2000 that is a collaboration of 33 member organizations to work together to promote the commercialization of FCEVs. In 2004, Hyundai, along with its partners - Chevron Corp. and UTC Power, began the test fleet having 32 units of '04 model FCEVs dispatched at southern California and Michigan area. This five-year cost-sharing program was sponsored by the U.S. Department of Energy (DoE). From 2006, Hyundai also started the test fleet in Korea as part of the FCEV learning demonstration led by the Ministry of Knowledge and Economy (MKE). This domestic operation has been expanded to accompany 30 units of '06 model FCEVs and four fuel cell buses, as well.

Hyundai triumphed in the 2007 Michelin Challenge Bibendum held in Shanghai, China with its '06 model FCEV featuring company's first in-house developed fuel cell stack, competing against teams from Daimler, GM and Nissan. The Hyundai's FCEV was the only participant to get a perfect score. Hyundai completed a 13 day, almost 4300 mile traveling from Portland, Maine to Los Angeles, California as part of the Hydrogen Road Tour 2008. Two '07 model FCEVs having the outsized fuel cell stack than their predecessor's were showcased in this cross-country, multi-manufacturer driving event demonstrating again that zero-

emission vehicles using hydrogen can operate in real-world driving conditions. Recently, Hyundai together with Kia took part in the Hydrogen Road Tour 2009 bringing fuel cell vehicles to the west coast in this time. Along with the Hyundai's FCEV, the same model shown in last year, the first introduced Kia's '08 model FCEV completed a 9 day, over 1700 mile road rally from Chula Vista, California to Vancouver, British Columbia.



Fig. 1. Hyundai-Kia's FCEVs reaching the finish line of the recent Hydrogen Road Tour

SPECIFICATIONS OF THE LATEST MODELS

The Hyundai Tucson FCEV is powered by a 100 kW-fuel cell stack, offering the fuel economy with 72 mpg city in virtue of the enhanced system efficiency as well as reduced vehicle weight using lightweight aluminum body shell components. The Tucson FCEV also retains the quick and efficient cold start and drive capability at sub-zero temperatures including -20°C . Meanwhile, the Kia Borrego FCEV is equipped with a 115 kW-fuel cell stack which is housed underfloor, not in the engine compartment as in the Tucson FCEV. Fueled with the hydrogen compressed at 700 bar, the Borrego FCEV is capable of running more than 450 miles per refueling. Propelled by a 110 kW-traction motor and a 100 kW-ultracapacitor coupled to the fuel cell stack, a top speed of 160 km/h and 0-60 mph times of 12.8 sec are achieved.