

Development and Advances of a V-Flow FC Stack for FCX Clarity

Hiroshi Morikawa, Hideaki Kikuchi and Nobuhiro Saito

Honda R&D Co.,Ltd.

Copyright © 2009 SAE International

ABSTRACT

Honda has succeeded in developing the new fuel cell (FC) vehicle designed into a dynamic, full-cabin sedan, the FCX Clarity, originating from the new V Flow FC platform. The key technology is V Flow FC Stack, featuring V Flow cell structure in which the fuel gases run from top to bottom vertically through the wave flow-channels. According to this unique structure, the fuel cell stack sits longitudinally along the center tunnel, and a Vertebral layout has emerged. The Vertebral layout results in Volume efficient package and low-floor platform. The V Flow FC stack has achieved a high output of 100kW and improved the output density with 50% by volume and 67% by mass, compared to the previous 2005 model. The V Flow cell structure utilizes gravity for water drainage and reduces the channel depth creating thinner cells. The wave-shaped vertical gas flow channel provides horizontal and more efficient coolant flow distribution allowing the reduction of the number of cooling layer. The thinner cells lead the conversion from the former two-box construction into one-box fitting efficiently into the center tunnel. The new V Flow FC Stack has made significant advances in the fuel cell stack technology.

INTRODUCTION

To respond to issues of global warming and the depletion of energy resources, Honda has "pushed the envelope" ahead of the industry with research and development (R&D) on fuel cells. Emitting no CO₂ or

environmentally-harmful substances, fuel cells are viewed as the ultimate clean, resource-recycling powerplant.

Honda first fitted a fuel cell stack developed in-house in an experimental fuel cell vehicle in September 1999. In October 2003, the company announced the development of the Honda FC stack, employing stamped metal separators with unitized seals and aromatic electrolytic membranes⁽¹⁾. The Honda FC stack achieved a high power density, and was able to start in cold sub-zero climates.

As a result of continuous efforts to innovate the configuration of fuel cell stacks, Honda was able in September 2006 to announce the development of its proprietary V Flow FC stack. This is a one-box stack using a V Flow cell configuration and wave flow channel separators, which dramatically reduced size and weight and increased power. A V Flow FC platform in which the V Flow FC stack was fitted in the center tunnel was developed, leading to the announcement in November 2007 of the FCX Clarity, a sedan realizing a next-generation package and design. Production of the FCX Clarity commenced in June 2008.

This paper will provide an overview of the V Flow FC stack configuration, which has realized significant weight savings and increased compactness, higher power and stability in electrical generation.

DEVELOPMENT OBJECTIVES

In order to respond to global warming and energy issues, to realize a next-generation package and design capable of changing the future of the automobile, and to produce a vehicle with the potential to be mass-produced in the future with a view to more widespread diffusion among the public, the following two points were established as the main objectives in the development of a next-generation fuel cell stack:

1. Increased package-ability via weight savings and volume size reductions
2. Increased power density and stability of electrical generation

V FLOW FC STACK

As Fig. 1 shows, polymer electrolyte fuel cells use polymer electrolytic membranes to directly convert the chemical energy into electricity from electrolytic reactions between hydrogen and oxygen.

Hydrogen electrode (−) : $\text{H}_2 \rightarrow 2\text{H}^+ + 2\text{e}^-$

Oxygen electrode (+) :

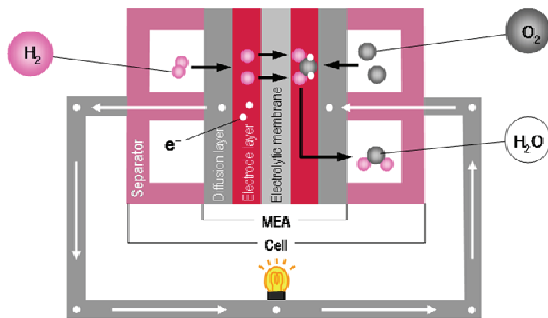
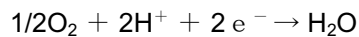


Fig.1 How electricity is generated in the fuel cell stack

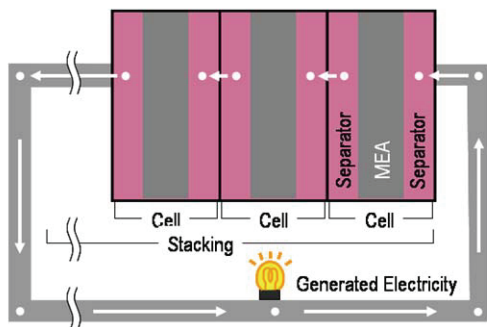


Fig.2 Fuel cell stack configuration

The polymer electrolytic membrane that transmits protons is sandwiched between two electrode layers (a hydrogen electrode and an oxygen electrode) and two diffusion layers, forming a membrane and electrode assembly (MEA)⁽²⁾. This MEA is sandwiched between two separators, forming one cell. Even when the circuit is open, the voltage produced by a single cell cannot exceed the theoretical voltage of 1.23 V. The cells are therefore layered as shown in Fig. 2, and a high voltage is produced as a result of adding up generated electricity in each cell. Because voltage is determined by the number of layers of the series cells and current is determined by the area of the electrodes in the cells, the achievement of increased power necessitates the use of greater number cells or the area expansion of the electrodes.

In addition, in order to maximize the generation performance of the cells, it is necessary to achieve a uniform flow of hydrogen, air and coolant over the electrode layer. If the water produced from the reaction between protons and oxygen accumulates in the gas channels, it can impede the flow of gas, preventing hydrogen and air from being supplied uniformly to the electrodes and making generation unstable. In addition, if the coolant does not flow uniformly, local areas of high temperature will form in the MEA, and the MEA will deteriorate in those areas.

In the V Flow FC stack, the development of a V flow cell configuration that increases water drainage capacity has enabled the achievement of increased stability in electrical generation and reduced cell thickness. In addition, the use of wave flow channel separators that help ensure a uniform flow of hydrogen, air, and coolant has improved generation performance and contributed to reducing the thickness of the cells by reducing the number of coolant layers.

The reduction of the cell thickness achieved through the use of these technologies has helped to enable the use of a one-box FC stack configuration rather than the two-box configuration previously employed (Fig. 3). As a result, volume-power density has been increased by 50% and weight-power density by 67%, against the previous stack, and packageability has been significantly improved (Fig. 4).

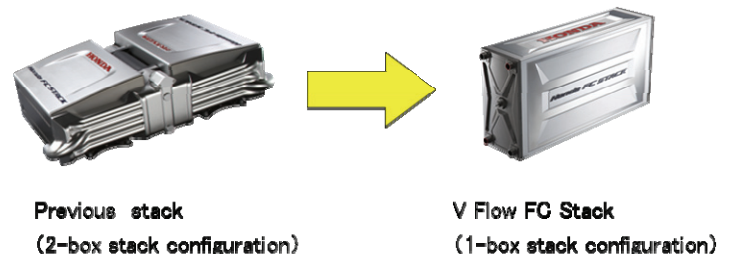


Fig.3 Evolution of stack construction