

Status of FCV Development at Nissan and Future Issues

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ABSTRACT

In the "Nissan Green Program 2010", released in December 2006, Nissan Motor Co., Ltd. announced plans to offer advanced technology and products to further real-world reductions in CO₂ emissions. One solution is the development of a practical fuel cell vehicle (FCV).

In 1996, Nissan began developing an FCV and since 2001, has participated in activities to promote the development and to educate the public on the benefits of fuel cell vehicles by participating in fleet programs in the USA (CaFCP) and in Japan (JHFC). In 2006, limited leasing of the newly-developed 2005 X-TRAIL FCV was initiated in Japan, in the Kanagawa Prefecture and in Yokohama City. In 2007, Nissan provided an X-TRAIL FCV to Kanagawa Toshi Kotsu Ltd., for use as the world's first-ever fuel cell taxi in use on public roads.

The 2005 X-TRAIL is equipped with various newly-developed technologies, including a fuel cell stack that was engineered by Nissan in-house. The X-TRAIL FCV has evolved from a test vehicle in 2002 to the model of today, which provides the utility and convenience required by the consumer in the market. The cruising range, acceleration performance and maximum speed are competitive with existing gasoline vehicles. However, to enable commercialization of the FCV, further improvements in performance and durability as well as reduction in cost will be necessary. Therefore, Nissan is investigating several different approaches to reduce cost and improve durability and performance.

The current Nissan R&D activities related to degradation mechanism understanding of the membrane electrode assembly (MEA) and to possible countermeasures developing for durability improvement is described.

INTRODUCTION

There are growing expectations that hydrogen-powered fuel cell vehicles (FCVs) will be an effective means of reducing the environmental impact associated with vehicle use, specifically by reducing atmospheric emissions of greenhouse gases like carbon dioxide

(CO₂). This is related to the high efficiency and zero emission characteristics of fuel cells and the fact that no CO₂ is emitted during vehicle operation. Vehicle manufacturers are moving ahead with R&D programs to develop FCVs. For example, Nissan is vigorously pushing forward with the development of FCVs as part of the development of various technologies for reducing vehicle emissions of CO₂ under the Nissan Green Program 2010 (NGP2010) announced in 2006.

This paper describes the present status of Nissan's R&D activities for FCVs and reviews the technical issues that need to be addressed to promote practical use of these vehicles. Special focus is put on the technological approach being taken to improve the durability of the MEA for automotive application and possible solutions to this issue.

HISTORY OF FCV DEVELOPMENT AT NISSAN

Nissan initiated R&D work on FCVs in 1996 and built its first prototype vehicle equipped with a methanol reformer system in 1999. That was followed by the development of the XTERRA FCV in 2001, which used high-pressure hydrogen as its fuel source. The XTERRA FCV was supplied to the California Fuel Cell Partnership (CaFCP) program for use in conducting public-road driving tests. In 2002, a prototype FCV based on the X-TRAIL sport utility vehicle was developed and approved by the Minister of Land, Infrastructure and Transport (Fig. 1). Nissan then began public-road testing of the vehicle under the Japan Hydrogen & Fuel Cell Demonstration Project (JHFC).

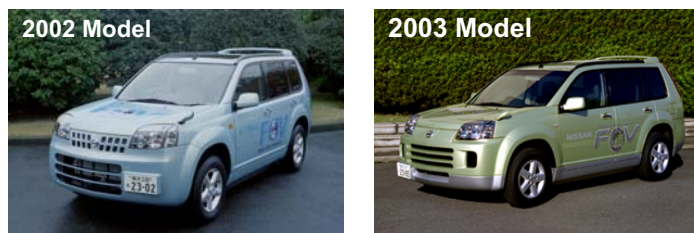


Fig. 1 X-TRAIL FCV Prototypes

A 2003 X-TRAIL FCV was then completed that was fitted with a newly developed fuel cell system, and

limited leasing of the vehicle was launched in December 2003. Subsequently, a 2005 X-TRAIL FCV was newly developed (Fig. 2) that was approved by the Minister of Land, Infrastructure and Transport in December 2005. Nissan began leasing the vehicle to the Kanagawa prefectural government and to the city of Yokohama in April 2006, as the successor of the limited leased 2003 X-TRAIL FCV to them. Test-drive sessions that enabled ordinary customers to actually test-drive an FCV were held every other week at Nissan's corporate headquarters in Tokyo. In addition, the X-TRAIL FCV was put in service in February 2007 as the world's first FCV taxi in business, thereby providing opportunities for a broad spectrum of the general public to experience the performance and attractiveness of FCVs.



Fig. 2 2005 X-TRAIL FCV Model

A brief explanation is given here of the 2005 X-TRAIL FCV model. Among other new technologies, this FCV is fitted with a new fuel cell stack that was developed in-house at Nissan. Compared with the previous 2003 FCV model, the vehicle performance of the 2005 X-TRAIL FCV has been markedly improved, particularly its driving range. In terms of practicality under ordinary operating environments, this FCV attains a level of performance comparable to that of conventional vehicles powered by an internal combustion engine (ICE).

VEHICLE SPECIFICATIONS

The major specifications of the 2003 and 2005 X-TRAIL FCV models are given in Table 1. Previously, the following technologies were respectively accumulated at Nissan in the process of developing the Hypermini electric vehicle, Tino Hybrid vehicle and the AD Van CNGV that operates on compressed natural gas:

- (1) a high-voltage traction motor and a lithiumion-battery system,
- (2) an energy control system, and
- (3) a high-pressure fuel storage system.

The 2003 and 2005 FCV models were developed on the basis of these core technologies. The 2005 model is virtually identical to the 2003 model in appearance, except for the body color, and in dimensions, except for

Table. 1 Specifications of 2005 X-TRAIL FCV Model
(70-Mpa specifications are given in parenthesis)

		2005 Model	2003 Model
Vehicle	Overall length/width/height (mm)	4485/1770/1745	
	Curb Weight	1790 (1860)	1960
	Seating capacity	5	5
	Top speed (km/h)	150	145
	Cruising range (km)	over 370 (over 500)	over 350
Motor	Type		
	Max. power(kW)	90	85
Fuel cell stack	Fuel cell	Polymer electrolyte type	
	Max. power (kW)	90	63
	Supplier	In-house	UTC Fuel Cell (USA)
Battery	Type	Compact Lithium-ion Battery	
Fueling system	Fuel type	Compressed hydrogen gas	
	Max. pressure(MPa)	35 (70)	

the vehicle height. (The overall height of the 2005 FCV model is lower by 55 mm owing to the discontinuation of the rear spoiler.) However, the vehicle weight has been significantly reduced by 170 kg from 1,960 kg to 1,790 kg (1,860 kg for the vehicle with the 70-MPa hydrogen cylinder).

As will be explained later, the weight reduction was achieved by reducing the weight of the newly developed fuel cell stack and the weight of the electric system.

MAJOR TECHNOLOGIES

VEHICLE PACKAGING

The in-vehicle layout of the principal components is shown in Fig. 3. The fuel cell stack and high-pressure hydrogen storage cylinder are located under the floor, and the traction motor, inverter and other electrical system components are located in the engine compartment. Nissan's Compact Lithium-ion Battery was located behind the rear seatback on the 2003 FCV model, but it is positioned under the luggage area floor on the 2005 FCV model. As a result, the luggage area length of the 2005 FCV model has been increased by approximately 400 mm for improved practicality. In addition, the diameter of the 35-MPa high-pressure hydrogen cylinder has been reduced by approximately 50 mm compared with the cylinder of the 2003 FCV model. That smaller size allows a lower sitting height for the rear-seat passengers, which improves ease of ingress/egress and rear-seat habitability. The smaller diameter of the 35-MPa hydrogen cylinder reduces the onboard hydrogen storage capacity by 20% compared with the 2003 FCV model. However, the driving range of the 2005 FCV model fitted with the 35-MPa cylinder has been extended by 20 km over that of the 2003 FCV model as a result of improving the efficiency of the fuel cell stack and reducing the vehicle weight, among other improvements.

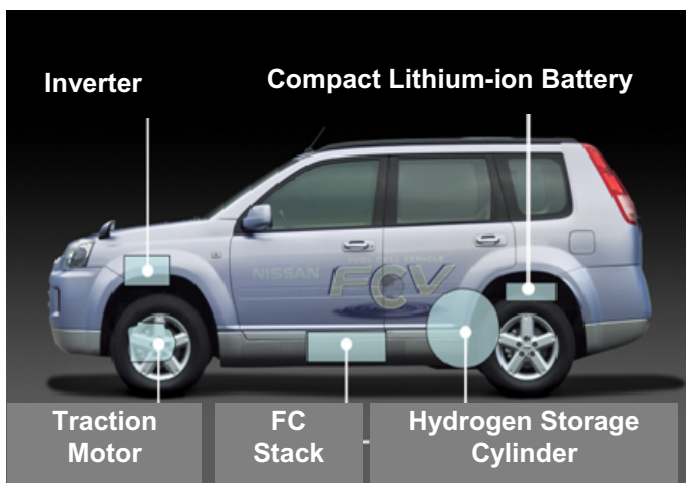


Fig. 3 Layout of Major Components

COMPONENT TECHNOLOGIES

Fuel cell stack

Figure 4 is a photograph of the new fuel cell stack developed in-house at Nissan. This newly developed fuel cell stack adopts a thin carbon separator that reduces the volume of the stack to approximately 60% of that of the fuel cell stack on the 2003 FCV model, yet maximum power output has been improved to 90 kW compared with 63 kW for the previous model. That improvement was achieved by improving the polymer membrane and optimizing the operating procedure. However, durability and other attributes are still not sufficient compared with an IC engine and will require further improvement in the future.



Fig. 4 In-house Developed Fuel Cell Stack

70-MPa high-pressure hydrogen cylinder

Figure 5 is a photograph of the 70-MPa hydrogen cylinder that was newly developed jointly for the 2005 FCV model with Dynateck Industries Ltd. of Canada. This cylinder raises the charging pressure twofold over the previous 35-MPa high-pressure cylinder. That increase boosts the hydrogen storage capacity by approximately 30% in the same outer volume compared with a pressure of 35-MPa. The new cylinder is made of an inner aluminum alloy liner and a carbon-fiber-reinforced outer shell. It has been certified by the High Pressure Gas Safety Institute of Japan (KHK) as a compressed hydrogen automotive fuel cylinder.



Fig. 5 70-MPa Hydrogen Cylinder