THE DEVELOPMENT OF SEVERAL 100 kW-CLASS TUBULAR TYPE SOLID OXIDE FUEL CELL SYSTEM (SOFIT)

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ABSTRACT

Electric Power Development Co., Ltd. (JPOWER) started SOFC development in collaboration with Mitsubishi Heavy Industries, Ltd. in 1991. When development of a pressurized SOFC 10 kW module was completed, radical improvement of the modular structure was performed, aiming for further improvement in reliability and lower cost. It has been checked that there is no technical problem in the new structure of SOFC module. We plan to examine several prototype 100 kW-class atmospheric SOFC co-generation systems (SOFIT) from 2006 to verify the SOFC system using the new structure module, and the reliability of more than 10,000 hours operation at JPOWER’s Chigasaki laboratory.

INTRODUCTION

Electric Power Development Co., Ltd. (JPOWER) started SOFC module development in collaboration with Mitsubishi Heavy Industries, Ltd. (MHI) in 1991. After several module development steps in both atmospheric and pressurized specification from 1 kW to 10 kW-class, an internal reforming technology that can achieve relatively higher efficiency was verified with a 10 kW-class pressurized SOFC module in 2001 (1) (Figure 1).

Many patents related to this SOFC module have been applied for by MHI, through our development with effective modifications based on our experience. SOFC cell characteristics poisoned by impurities and fuel diversity characteristics and so on, has been studied at our Chigasaki laboratory (2).

After a successful test with a 10 kW-class pressurized SOFC with internal reforming, fundamental improvement of a modular structure was performed, aiming for higher reliability and lower cost.

In this paper, the recent development status of our new structure of SOFC module and a future plan for several prototype 100 kW-class atmospheric SOFC co-generation system (SOFIT) are described.
DISCUSSION

Concept of New Structure SOFC Module

The new structure SOFC module has the following features, aiming for improved reliability not only during normal operation but also during transportation and possible earthquakes, and lower cost coupled with GenSets and existing/proven technologies (Figure 2):

- One way fuel flow, simple design
- Both end cell support, eliminating the excess physical/mechanical stress
- Cartridge structure, easy to maintain.

![Figure 2. Old and new structures comparison.](image)

1 kW-Class and 5 kW-Class (Cartridge) Development

The concept of new structure design was verified with an atmospheric 1 kW-class module consisting of 31 cell tubes in 2002. Then the 5 kW-class module test was successfully conducted with 104 cell tubes under a pressurized environment in 2003. The MHI multi segment-in-series tubular cell configuration is 28 mm OD and 1200 mm in length. The cartridge specification is shown in Table I.

| Item          | Specification                          |
|---------------|----------------------------------------|
| Cell Tube     | Form OD 28 mm x length 1200 mm         |
|               | Output About 60 W                      |
| Cartridge     | Cell number 104                        |
|               | Output About 6 kW                      |
| Fuel          | Hydrogen and reforming imitation gas   |
| Operation temperature | 900°C   |
| Operation pressure   | 0.4 MPa   |

More than 1000 hr continuous operation with accumulated 1400 hr operation was achieved with the 5 kW-class cartridge test using hydrogen and simulated methane reformed gas. Through this test, including one heat cycle (H/C) showing no degradation,
we concluded that the concept of the new structure was well verified. The trend graph of major module performance data is shown in Figure 3 and the comparison of cell performance before and after heat cycle (H/C) is also shown in Figure 4.

Plan for Prototype Several 100 kW-Class Atmospheric SOFC Cogeneration System

Because the new structure was successfully verified with the cartridge, in collaboration with MHI, JPOWER will plan to examine the several 100 kW-class atmospheric SOFC cogeneration system (SOFIT) prototype from summer 2006, aiming to verify system durability through long-term operation for more than 10,000 hours.

Outline of SOFIT plan

The net power generation is planned to be 150 to 200 kW (DC) with approximately 45% LHV efficiency. Flue gas from SOFCs will be used for cogeneration using a chiller. This system will be owned and operated by JPOWER, who will operate it for more than 10,000 hours. The system flow diagram is shown in Figure 5.
The SOFIT will be installed at the JPOWER R&D Center (Chigasaki City, Kanagawa Prefecture, Japan). The test will run for approximately two years starting in the summer of 2006 (more than 10,000 hours). System specifications are cogeneration (CHP); power generation plus air conditioning. The fuel used will be methane base town gas (13A).

![Figure 5. SOFIT atmospheric pressure 100 kW SOFC system configuration.](image)

**Future Activities**

First, we will design a SOFC CHP system (SOFIT) based on the knowledge obtained through the new structure SOFC module development; in collaboration with MHI, planning for the startup of the SOFIT system will begin in summer 2006. JPOWER will own and operate the SOFIT system and promises to continue SOFC combined system study in parallel with cogeneration, IGFC, etc.

Then JPOWER, as a collaborative operations partner, has a plan to participate in the NEDO grant project, “a pressurized SOFC module with gas turbine combined system (350 kW) development,” that will be managed by MHI starting in 2006.

SOFCs are very promising to achieve very high power generation efficiency—more than 65%—with the triple combined cycle system of a pressurized SOFC, bottoming gas turbine (GT) and steam turbine (ST). Furthermore, JPOWER has a vision to develop IGFC, the ultimate clean coal power technology, which will be combined with SOFC and a developing coal gasification system (EAGLE).

**CONCLUSIONS**

JPOWER initiated SOFC module development in collaboration with MHI in 1991. Then we were challenged to develop a new structure SOFC module, aiming for higher reliability and lower cost, after a successful test with a 10 kW pressurized SOFC with internal reforming. Because the new structure was successfully verified with the cartridge in collaboration with MHI, JPOWER plans to examine several prototype 100 kW-class atmospheric SOFC cogeneration systems (SOFIT) starting in 2006, to verify system durability through long-term operation of more than 10,000 hours.

**REFERENCES**

1. Konishi, et al., in *Extended Abstracts of the 10th Symposium on Solid Oxide Fuel Cells in Japan*, p. 53, the Solid Oxide Fuel Cell Society of Japan, (2001).
2. Komiyama, et al., *ibid*, p. 59, (2001).