Development of Tubular Type SOFC Module

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Solid Oxide Fuel Cell(SOFC) is one of the key technologies for the energy problem because of its high electrical efficiency. TOTO Ltd. has been developing SOFC for more than 10 years. The cell design is a tubular type and a feature of our cell is a cell manufacturing method by wet process. This paper shows development of a several-kW-class Module(1st MODULE) which should be thermally sustainable. The development is going on in the national SOFC Project by NEDO from 2001.

The planned specifications of the 1st Module are shown in Table 1. The power output should be 6.7kW DC using natural gas as fuel. And the degradation rate should be less than 0.25%/1000Hr. The number of cells is 240.

The tubular type cell has 0.6m of length and 16mm of outer diameter. Active anode area is 170cm^2. A Bundle consists of 15 cells which has 3 × 5 arrangement.

Figure 1 shows an appearance of a Main-Module and a Sub-Module. The Sub-Module consists of 4 Bundles and that includes 60 cells. The Sub-Module is a fundamental unit for construction, and the Main-Module consists of 4 Sub-Modules.

Figure 2 shows the system configuration of the 1st Module. Two start-up burners are located at the bottom of the Main-Module. They supply heat and reducing gas for start-up of the system. In the air supply line, there is an air heat exchanger for pre-heating air using heat of exhaust gas. In the fuel supply line, there are a desulfurizer which is operated under room temperature, an electric vaporizer, a fuel heat exchanger for pre-heating fuel using heat of exhaust gas and a reformer which is set in a combustion room. In the combustion room , exhaust gases from anode and cathode mix and burn. Then the high temperature combustion gas supplies heat for reforming.

Figure 3 shows a I-V performance of the 1st Module using Hydrogen in the TEST1 and TEST2. The maximum power output was 3.2kW DC at a fuel utilization of 65%. The power output was lower than that of a plan, but the module indicated no degradation between TEST1 and TEST2 in spite of thermal cycling to room temperature.

Figure 4 shows a I-V performance of the 1st Module using natural gas in the TEST3. The result was obtained with a half module(120 cells) . The maximum power output was 1.5kW DC at a fuel utilization of 41%. Heat loss in the system was so large and it was necessary to use much fuel to supply heat for reforming in the combustion room. That was a reason of low fuel utilization in the natural gas case.

Analysis of energy balance shows the possibility of thermally sustainable module by using the heat of exhaust gas and heat loss for vaporization though electric heater was used for vaporization in the test.

The 2nd Module is going to be constructed in the latest period of 2002. It is expected to demonstrate maximum performance of the module by the compact module design and by decrease of heat loss.

Table 1. Specifications of 1st Module (PLAN)

Fuel	Natural Gas (Town Gas 13A)
Power Output	6.7kW DC
Fuel Utilization	≧75%
Degradation Rate	≦0.25%/1000Hr
Number of Cells	240

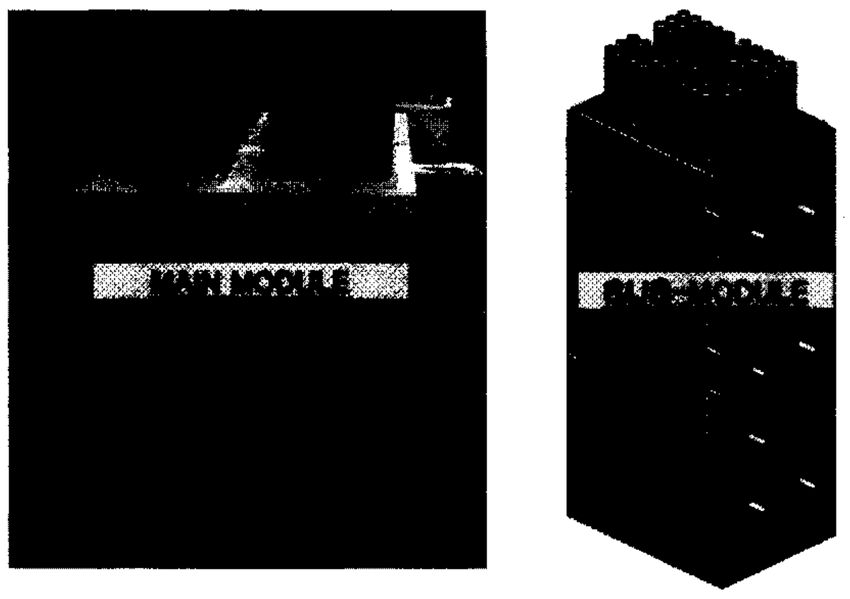

Figure 1. Main-Module and Sub-Module

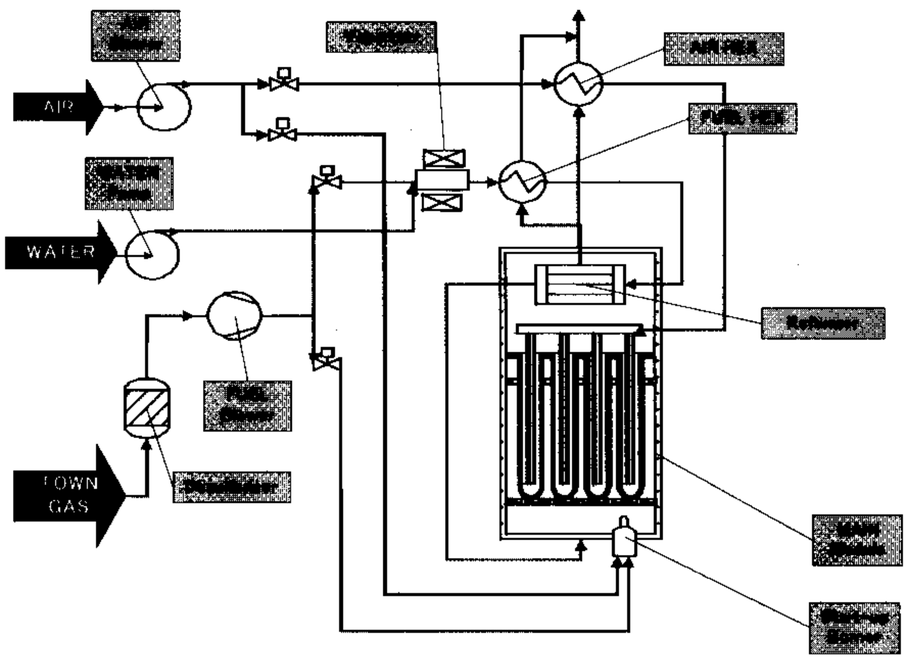

Figure 2. System Configuration of 1st Module

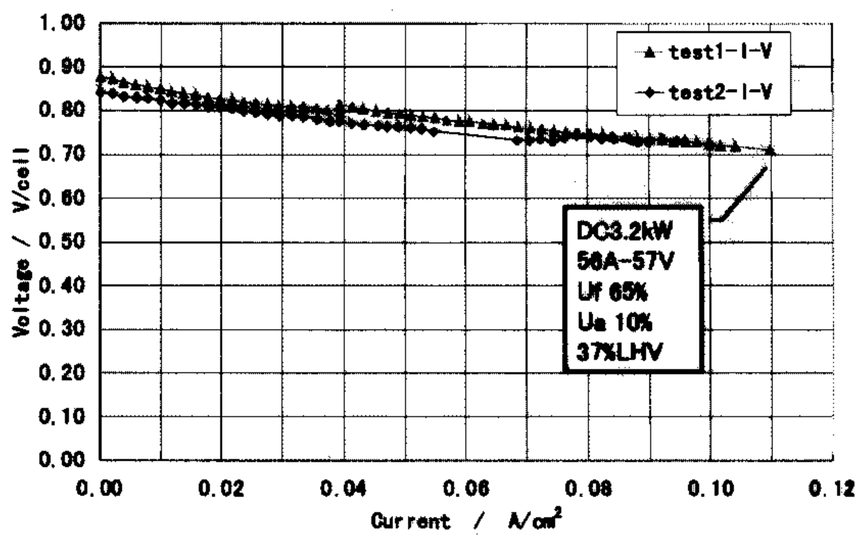

Figure 3. I-V Performance using Hydrogen

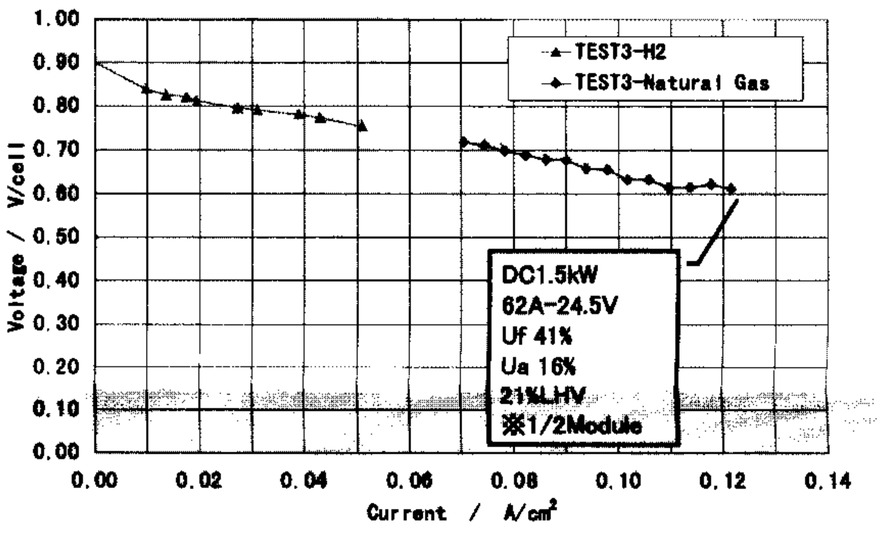

Figure 4. I-V Performance using Natural Gas