Efforts toward Introduction of SOFC-MGT Hybrid System to the Market

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Mitsubishi Hitachi Power Systems, Ltd. (MHPS) delivered the demonstration unit prototype to Kyushu University for the commercialization of the SOFC-MGT hybrid system, and now the cumulative power generating time has exceeded 10,000 hours. In addition, in the program subsidized by National Research and Development Agency New Energy and Industrial Technology Development Organization (NEDO), demonstration systems have been set up at four locations in Japan, and the verification of durability and the demonstration through start/stop tests and load change tests in an actual load environment have been conducted toward introduction to the market since 2015.

1. Introduction

Recently, the energy situation in Japan has reached a major turning point, and it seems that awareness of high-efficiency power generation and power security has increased. In cases where fuel cells, which can generate power with high efficiency, are used as a distributed power source, it is important to combine location and capacity in the best mix based on the current power basic infrastructure constructed by the centralized power source such as thermal power generation. In Japan, the industrial sector accounts for more than 40% of all energy consumption, and the consumer and industrial sectors account for slightly more than 60%. It is considered that the spread of the use of fuel cells in the commercial field is one of the effective measures for improving the Japanese energy situation.

MHPS has focused on developing the high-efficiency SOFC (Solid Oxide Fuel cell) hybrid power generation system with a very wide range of power output. The system covers everything from medium-capacity (250 kW class) distributed power sources to large-capacity centralized power sources including Gas Turbine Fuel Cell (GTFC) combined cycle and Integrated Coal Gasification Fuel Cell (IGFC) combined cycle technologies, which are advocated by the "Council for promoting the early achievement of next-generation thermal power generation" of the Ministry of Economy, Trade and Industry.

2. Composition of SOFC-MGT hybrid system

Figure 1 illustrates the structure of a cell stack which is a power generation element of tubular type SOFC. On the outer surface of the substrate tube, which is a structural member made of ceramic, a cell (laminated anode, electrolyte, and cathode) reacting to generate power is formed and an electron-conductive ceramic interconnector connects these cells in series. Several hundred cell stacks are bound to form a cartridge, and several cartridges are contained in a pressure vessel. This is called an SOFC module (**Figure 2**).

This system consists of the SOFC, Micro Gas Turbine (MGT), recycle blower, etc. Power is generated in the two stages of the SOFC and MGT, and furthermore, if waste heat recovery equipment is installed on the exhaust gas line, it can then utilize a co-generation system that supplies steam and hot water at the same time (**Figure 3**).

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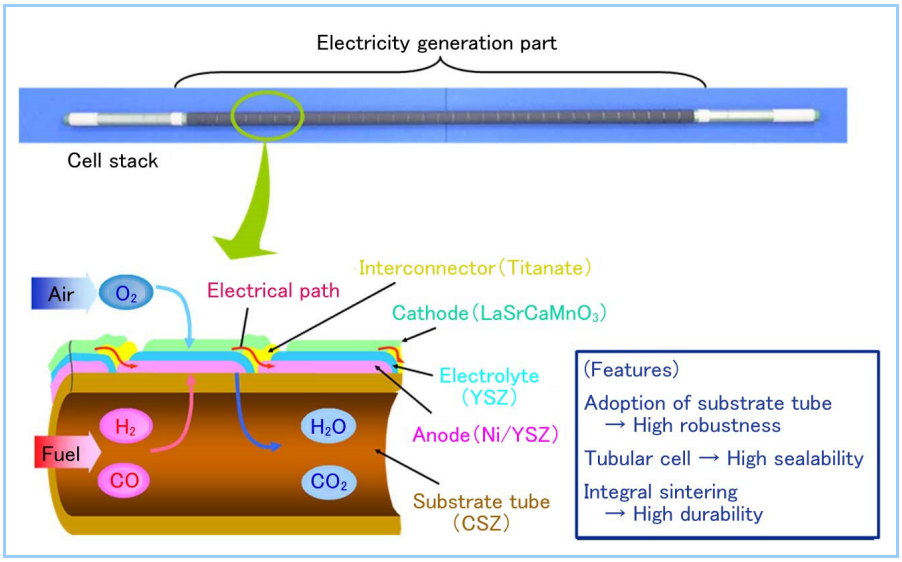

Figure 1 Structure of cell stack

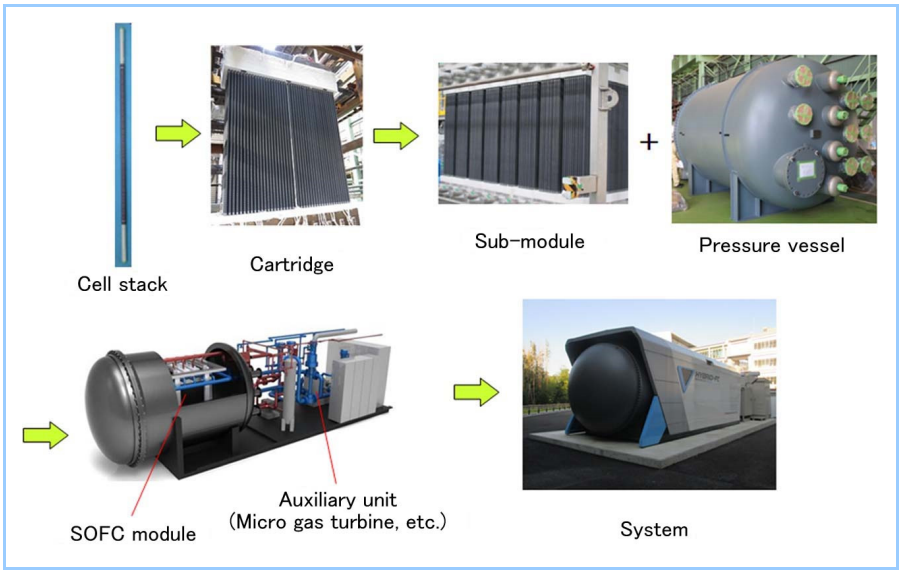

Figure 2 Composition of hybrid system

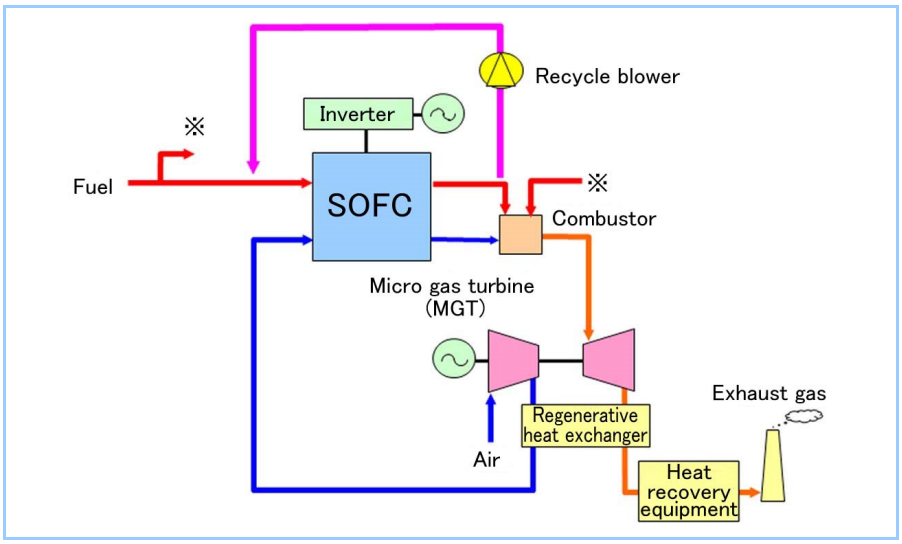

Figure 3 Hybrid system

3. Actual operational results of the demonstration system at Kyushu University

The "Next-Generation Fuel Cell Research Center (NEXT-FC)" was established on the Ito Campus of Kyushu University (Nishi-ku, Fukuoka) aiming to fully disseminate SOFC by promoting industry-academia cooperation. The Center has conducted demonstration research under the "Verification of a Smart Fuel Cell Society" in the Green Asia International Strategic Comprehensive Special Zone, as well as fundamental research for enhancing the related SOFC's performance, durability and reliability.

MHPS delivered the prototype unit of the SOFC-MGT hybrid system to Kyushu University and started the demonstration operation in the spring of 2015. This prototype unit adopts a mono-generation system.

Various tests such as load elevation and restart testing from the cold shutdown state or hot standby state are conducted to establish an operational control method for full automatization. In addition, a remote monitoring system was constructed on this prototype unit, so that the operational status can be remotely monitored in real time and the operation can be remotely conducted.

Since the operation started, the prototype unit has experienced various environments such as earthquakes (intensity of lower 5), typhoons, heavy rainfall, snow cover, and power interruptions. But the fuel cell has not been damaged and has continued stable power generation. As of now, a cumulative total of more than 10,000 operating hours have been achieved, and the verification of long-term durability will be continued.

4. Efforts in NEDO-subsidized project

Under the NEDO-subsidized project "Technical demonstration of commercial system using solid oxide fuel cells," demonstration tests in an actual load environment were started toward introduction to the market.

The demonstration sites consist of four bases: the Motomachi Plant of Toyota Motor Corporation, the Komaki Plant of NGK Spark Plug Co., Ltd., Senju Techno Station of Tokyo Gas Co., Ltd. and the Technology Center of Taisei Corporation (**Figure 4**).

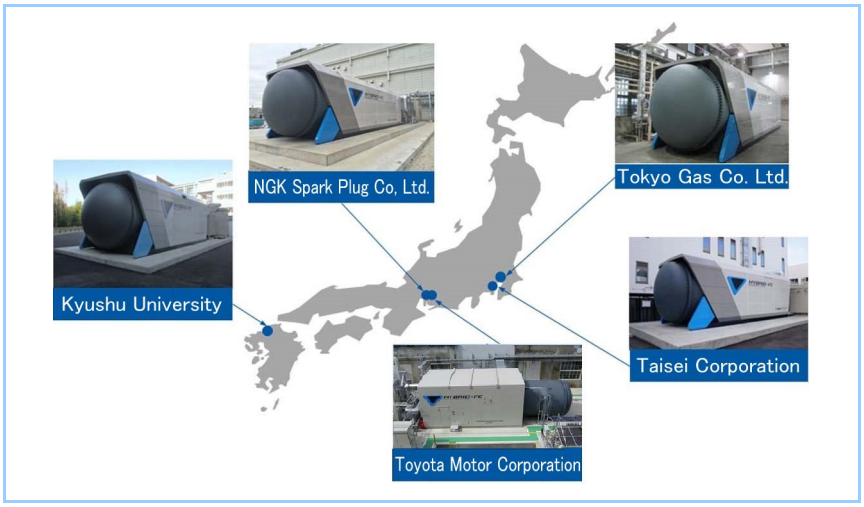

Figure 4 Prototype unit at Kyushu University and demonstration systems for NEDO-subsidized project

In this subsidized project, the respective main subjects/verification items have been set at each site and the demonstration tests have been conducted. The details of the demonstration test at each site are as described below. All the demonstration systems are co-generation systems, and remote monitoring was conducted.

The demonstration system at Toyota Motor Corporation: The system as a power generation equipment for achieving a low carbon society was operated based on the assumed electric power demand at the plant and the start/stop tests were conducted about once a month to assess the effects of changes in power demand and start/stop operation on the performance and durability.

The demonstration system at NGK Spark Plug Co., Ltd.: The cell stack manufactured by

NGK Spark Plug Co., Ltd., and the cell stack manufactured by MHPS were mounted, and were checked through long-time continuous operation as to whether the performances of both cell stacks were uniform.

The demonstration system at Tokyo Gas Co., Ltd.: Repeating start/stop tests, such as hot restart simulating DSS (Daily Start and Stop) operation and restart simulating WSS (Weekly Start and Stop) operation were conducted to evaluate durability. For the purpose of expanding the serviceability of the hybrid system, the load changing test and the load following test were conducted.

The demonstration system at Taisei Corporation: The system has a self-sustaining function which allows continuous power generation if fuel can be supplied even in the event of power failure. Therefore, checks of the self-sustaining function and verification with partial load were conducted. Compared to demonstration systems at the above three sites, this system is simplified and compact in size (volume/length reduced by 23%) to reduce associated costs.

Based on the results of the demonstrations at the four aforementioned sites, we will determine the product specifications and promote introduction to the market.

5. Conclusion

In June 2014, the Ministry of Economy, Trade and Industry developed the Strategic Roadmap for Hydrogen and Fuel Cells, which definitively states that commercial and industrial fuel cells will be introduced to the market in 2017.

MHPS will position the SOFC hybrid power generation system as a key effective technology for making the reduction of CO_2 emissions and the stable supply of power compatible, steadily establish technologies toward early commercialization, and greatly contribute to the establishment of a "safe and sustainable energy environment society."

References

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