PRESENT STATUS OF THE R&D ON MCFC IN CRIEPI/JAPAN

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Keywords; MCFC, CRIEPI, Japan

Introduction

Molten Carbonate Fuel Cells (MCFC) power plants are expected to have high generation efficiency and to be favorable for environmental protection. In Japan, recently, many electric utilities are interested in this technology.

R&D on MCFC technology in Japan has been started under the Moonlight Project of the Agency of Industrial Science and Technology, Ministry of International Trade and Industry. Currently, the R&D is concerned not only with MCFC stack technology but also with balance of plant (BOP) technology for a 1MW pilot plant. Moreover, other national or private research programs concerned with the MCFC are in progress.

CRIEPI has participated in the Moonlight Project as a representative of all Japanese electric utilities, and has been in charge of the total system study and stack operating study from the beginning. In addition, CRIEPI has been conducting collaborative projects with several companies, to support the Moonlight Project and to accelerate the introduction of MCFC technology into Japanese electric utilities. In these projects, a number of cells and stacks have been constructed and operated, and their performance has been constantly improved. Some issues remain to be solved, especially, life and energy density improvement to reduce cost. It is necessary to accumulate basic operational data systematically and to understand long-term performance. Recently, research has focused on these data.

In this paper, the status of R&D on MCFC in Japan is introduced, and selected results achieved in CRIEPI projects are described. Moreover, CRIEPI's future plans for R&D are is also introduced.

Status of R&D on MCFC technology in Japan

Moonlight project[1]

R&D in Japan is mainly conducted under the Moonlight project. The target of this project is the development of a 1MW external reforming MCFC pilot plant. Fig.1 and Fig.2 show the organization for MCFC development under the Moonlight Project and the

R&D schedule, respectively. As for the fuel cell stacking technology, two types of 100kW external reforming stacks and a 30 kW direct internal reforming stack are being developed. All of stacks are to be operated by September 1993 for intermediate evaluation.

Furthermore, as for BOP technology, two types of fuel reformers, a high temperature gas recycle blower, a turbine compressor, a heat recovery steam generator and total plant control methods are being developed by the MCFC Research Association. All of their equipment is to be demonstrated by September 1993, as are the MCFC stacks.[2]

Moreover, stack operation technology to optimize its operation conditions is being developed and a total system study to clarify the image of future MCFC power plants and support technology ,i.e. material development, gas clean-up technology for coal gasified gas and so on, are being undertaken with a view of the future.

Joint research program of Kansai Electric Power Company and Mitsubishi Electric Co.

Kansai Electric Power Company is the second-largest electric power company in Japan. It has been conducting development on Indirect Internal Reforming (IIR) MCFC stacks under a joint research project with Mitsubushi Electric Company since 1988. In this project a 100kW stack has been operated for 2,308 hours during 1992.[3] Recently, the next phase in this joint research program has been addressed. This concerns the development of modified IIR stacks technology and the simple system technology.

Review of the R&D in CRIEPI

CRIEPI has been conducting R&D on MCFC technology since 1980 as one of the future key technologies for electric power utilities and has also been participating in the Moonlight Project since 1981.[4] Thus far, a number of cells and stacks have been operated under a collaborative research agreement with various Japanese developers such as Hitachi, Ltd., Ishikawajima-Harima Heavy Industries Co.,Ltd.(IHI), Mitsubishi Electric Corp.,Fuji Electric Co., Ltd. and Toshiba Corp., to support the Moonlight project and to accelerate the introduction into Japanese electric utilities. Table 1 shows the history of the R&D objectives in CRIEPI.

Stack operation technology

It is necessary to realize high performance and reliability of the stack itself in actual operation. To obtain high performance, pressurized operation and high utilization are desirable. To ensure high reliability in large-scale stack operation, uniform gas flow and uniform temperature distribution are required. Therefore, it is important to develop the operation technology as well as the stack design technology.

CRIEPI has installed a 10kW class test facility with several gas recycling loops in 1988, to test the operation technology of large-scale stacks.[5] Using the facility, a 6kW and a 10kW class stacks have already been operated under collaborative research agreements with IHI. In the operation of the 6kW class stack, it was confirmed that their gas recycling techniques are suitable for MCFC stack operation.[6] The 10kW class stack has been operated for about 4000 hours under pressurized and high fuel utilization conditions in 1991, by means of anode and cathode gas recycling techniques.[7] (Fig.3)

CRIEPI is also in charge of the stack operation study in the Moonlight project. Based on the above operation results, a 100kW test facility was designed and constructed in 1993 ,and one of the two 100kW stacks developed in the project is now being operated in this facility.

Cell and stack evaluation technology

To evaluate and improve the MCFC technology, it is important to accumulate and evaluate operation data under conditions close to actual use. CRIEPI has conducted several operation tests with bench-scale cells and stacks, and a large number of data have been accumulated and analyzed. From these data it was concluded that pressurized operation is suitable to achieve higher performance, because it reduces cathode reaction resistance.[8,9] (Fig.4)

Pressurized operation, however, accelerates nickel cathode dessolution into the electrolyte matrix. Deposition of the dessolved nickel in the matrix may lead to failure of the cell, caused by internal short circuit. To understand this phenomenon, experiments on nickel dissolution under more severe conditions were carried out under a collaborative research agreement with Mitsubishi Electric Co.. The effects of the partial pressure of carbon dioxide in cathode gas and of the thickness of electrolyte tile on nickel dissolution and shorting have been clarified with bench-scale cells.[10] (Fig.5)

System analysis technology

It is necessary to clarify the MCFC plant image and its performance preliminary to introducing it into electric utilities. Several kinds of MCFC power plants, i.e. LNG fueled, coal-gas fueled and co-generation plants, have been designed conceptually thus far, under in-house research and as part of the Moonlight Project.[11]

From these study it has been concluded that, in order to satisfy the requirements of electric power utilities, external reforming MCFC plants must be pressurized and the MCFC stacks must high energy density.

R&D Strategy of CRIEPI

From the results presented here, it is clearly important to improve the life time and energy density of MCFC stacks. To solve these issues, continued long-term and high energy density operation data will be accumulated systematically under collaborative research agreements with Hitachi, IHI and Mitsubishi Co., respectively. In addition, to obtain long-term performance experience, several experiments with bench-scale cells will be carried out by CRIEPI working with electric utilities.

To optimize cathode operation, which is a key to longer MCFC life and high energy density, more basic studies, clarifying the reaction mechanism under high pressure operation and studying the interfacial phenomena between electrode materials and electrolyte, are needed. Research on these topics has been started in collaboration with Tohoku University, Japan and Illinois Institute of Technology, Chicago, U.S., respectively.[12]

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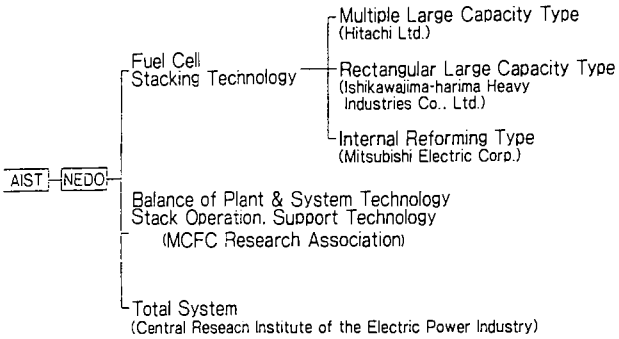

Fig. 1 Organization of MCFC Development in the Moonlight Project

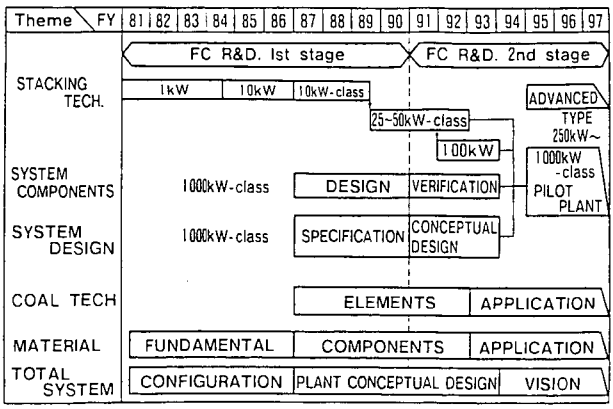

Fig.2 R&D Program on MCFC Power Generation in the Moonlight Project

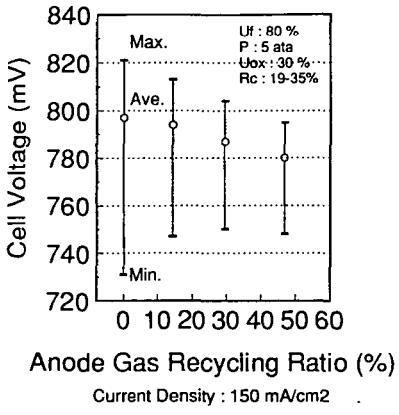

Fig. 3 Effect of anode gas recycling on a MCFC stack

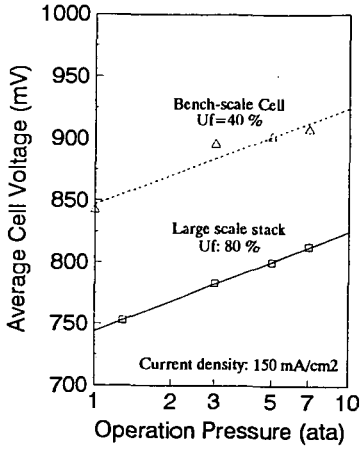

Fig. 4 Effect of operating pressure on cell performance

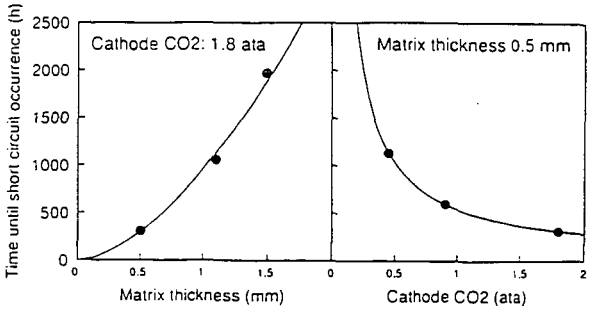

Fig. 5 Effects of matrix's thickness and CO2 partial pressure on the start time of internal short

Table 1. Trend of R&D Items in CRIEPI

Year	R&D Items
1980 to 1984 :	Evaluation of single small cell performance
1984 to 1989 :	R&D on cell and stack evaluation technology •Evaluation of single cells and stacks up to 1kW class •Development of operation technology on large-scale stacks
1989 to 1992 :	R&D on cell and stack evaluation technology •Improvement of stack performance up to 10kW class •Evaluation on pressurized condition R&D on MCFC plant technology •Establishment of gas recycling technology •Conceptual design of MCFC power plant

Table 2. R&D Schedule of CRIEPI

•Development of higher energy density stacks
Two 10kW class stacks will be operated by 1995 under higher current density (over 200mA/cm^2).

•Evaluation of the relationship between operation conditions and cell life.
Several bench-scale cells will be evaluated by together with electric utilities.

•Optimization of cathode electrode for higher energy density and long-life cells.
Basic data for the optimization will be accumulated by together with Tohoku University and IIT.