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DEVELOPMENT OF ON-SITE FUEL CELL POWER UNITS : FUEL CELL STACKS

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1. FOREWORD

Fuel cell stacks are the largest, heaviest, and costliest parts of on-site fuel cell power plants.

Therefore, to reduce the size and weight, which are the most important to on-site fuel cell power plants, it is essential to reduce the size and weight of the fuel cell stack. Reducing the size and weight of the fuel cell stack also has a large effect on reducing the material cost, which occupies a large part of the cost.

Improvement in the reliability and maintainability of the fuel cell stack is also important in putting fuel cells to practical use.

The main development items for doing this are:

(1) Reduction of electrode area and number of cells (unit cell) by development of high power density cell electrode.

(2) Reduction of cell thickness and number of cooling plates by development of high performance and high strength electrode substrate and separator.

(3) Reduction of the size and weight of the clamping parts and manifold and other mechanical parts.

(4) Development of cooling plate with high heat conductivity and electric insulating structure.

These items are introduced below.

2. DEVELOPMENT TARGET

The fuel cell stack development target specifications are shown in *Table 1*.

3. STRUCTURE AND DIMENSIONS

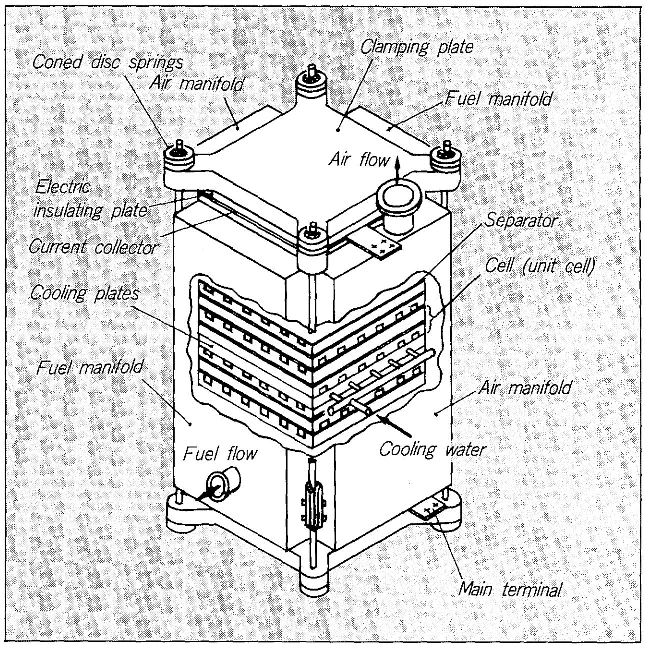
The structure of the fuel cell stack is shown in *Fig. 1*. The fuel cell stack is fabricated by cells (consisting of an anode, cathode, and a matrix for holding the phosphoric acid electrolyte) and separators for separating the reaction gas placed between the cells and cooling plates at each multiple cells. The fuel cell stack also has clamping plates to apply the necessary compression stress to the current collectors electric insulating plate, and cells.

The manifolds are placed around the fuel cell stack and is installed by a spring.

Table 1 Development target specifications of 50kW class fuel cell stack

Power density	0.2W/cm^2
Working pressure	Normal pressure
Average operating temperature	190°C
Effective electrode area	2,000cm^2 class
Electrode construction	Ribbed substrate
Cooling method	Water cooling

Fig. 1 Structure of fuel cell stack



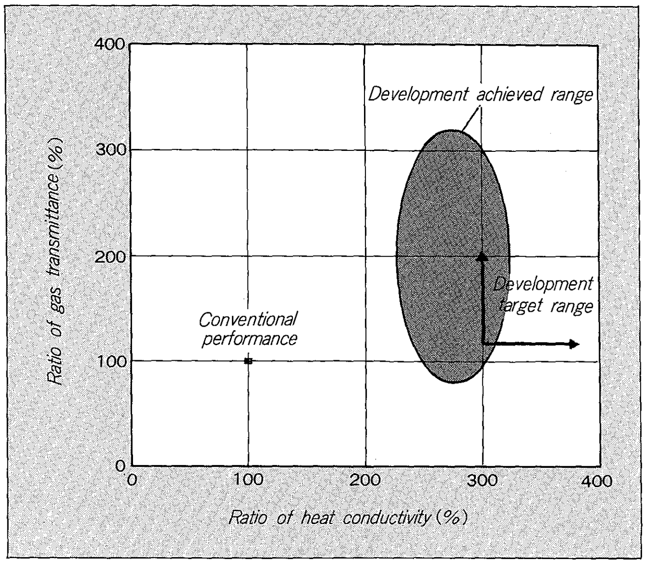
4. CELL

Various developments were made to also reduce the size of the fuel cell to correspond to the reduction of the size of the generating unit.

Regarding the electrodes, efforts are being made so that the cell dimensions are kept small and the number of cells used is made as small as possible by increasing the high power density.

To obtain the largest effective electrode area, the cells are constructed to minimize the dimensions of the seal around the cell. The height of each component material was also made smaller. Examples are thinning of the electrode substrate by optimization of the size of the gas grooves and development of the thin separator plate. A high heat conductivity electrode substrate was also developed to reduce the number of cooling plates. The rise of the current density caused by increasing the power density of the electrode is also accompanied by an increase of the heat generated. Thus, to maintain the uniformity of the cell temperature distribution between cooling plates, the number of cooling plates must be increased. To prevent this, the heat conductivity of the electrode substrate must be improved. Since this and the rise of the current density also increase the consumption of air and fuel at each cell, the gas transmittance of the electrode substrate must also be improved. Therefore, its development was promoted with improvement of the heat conductivity and gas transmittance of the electrode substrate as the main development targets. The current state of electrode substrate development is shown in *Fig. 2*.

Fig. 2 State of electrode substrate development



5. MECHANICAL PARTS

This section mainly discusses the state of development of the clamping plates, mainfolds, cooling plates, and other mechanical parts.

(1) Clamping plates

The clamping plates applie the necessary compression stress to the cells, cooling plates, current collectors, and other parts making up the stack for efficient output. Regarding development to make the clamping plate more compact and lighter weight, the functions required of the clamping plate were re-evaluated and design studies based on these were conducted so that the minimum required functions were satisfied and a prototype was made.

(2) Manifolds

The manifolds feed and discharge the fuel and air necessary for reaction at the stack. To reduce the size of the generating unit, the manifold should be made as small as possible as long as the uniform distribution of the fuel and air to each cell is satisfied.

The manifold was made more compact by study of uniform distribution and optimization of the layout of the parts.

To reduce the weight of the manifold, thin plate was used and a reinforcing structure which withstands the internal pressure was studied.

(3) Cooling plates

A water cooling system is used to efficiently remove the heat generated with reaction of the fuel cell to the outside of the cell. The cooling plates for this purpose has a construction with cooling tubes embedded in carbon plates.

To increase the performance of the cooling plates, the cooling plates were made thin. Moreover, to optimize the shape so that the carbon plates and cooling tubes contact area is increased and the contact resistance is reduced, experiments were conducted on the structure and structural material and were reflected in mechanical design.

Cost reduction was also studies over a wide range, including overseas procurement, to find low cost material.

(4) Insulation structure

Multiple cooling plates are inserted into the fuel cell stack, but because the potential of each cooling plate is different, they must be electrically insulated. Insulating coupling was used for this purpose. To lower the cost of this insulation structure, material search and structural studies to reduce the number of parts were conducted.

6. CONCLUSION

Various developments were made to substantially lower the cost, reduce the size, and improve the maintainability of the on-site fuel cell. Development will be continued to lower the cost and reduce the size of the on-site fuel still further in the future.