POTENTIAL APPLICATIONS OF FUEL CELLS

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Summary

Potential applications of fuel cells extend from the applications in commercial sectors to the electric utility applications, and allow us to envisage the future alternative energy system. For instance, mobile power application ultimately allows emission free automobiles, and the systems using hydrogen obtained from renewable energy sources enables a carbon dioxide free energy system into the far future. However, research and development activities are still required for establishment of the technology.

1. Introduction

Fuel cell-based electric power generation systems convert the chemical energy of the fuel directly into electricity. Hence, if hydrogen can be utilized directly as the fuel, a high electric power generation efficiency can be expected. There are also environmental benefits such as elimination of NO_x and other polluting emissions, and suppression of noise generation. Furthermore, fuel cells operating at high temperatures can be combined with gas turbines, steam turbines and other electric power generation equipment, so that they can comprise a combined cycle power plant. Such combined cycle plants can convert energy efficiently, using energy that is otherwise wasted in a simple cycle (or each individual power generation device). As a result, even higher power generation efficiencies are possible. When considering the features of fuel cells, one consideration is the types of fuel that can be used. Though some may not apply to certain types of cells, there is a wide variety of fuel choice; i.e., methane, natural gas, methanol, propane, naphtha, kerosene, coal gas and other fuels. Because of this diverse range of fuels, a variety of applications are conceivable. Other features include the ability to produce direct-current electric power, and the ability to operate without the need for large quantities of ocean or river water for cooling, which is required in the case of steam turbine generator plants. This reduces constraints on siting. These and many other features are capable of producing added value, and many different modes of application are currently being considered.

The general configuration of a fuel cell-based electric power plant consists, in addition to the fuel cells themselves, of a number of subsystems. However, the combination of subsystems used will differ with the type of fuel cell employed, the fuel used, and the plant application. Major subsystems include a fuel processing system to convert the fuel supplied into a form suitable for use with the fuel cells; an air supply system, to supply the oxygen (air) necessary for the cell reaction; a DC-AC conversion system, to convert the DC power generated by the cells into AC; a waste heat recovery system, to recover the heat generated within the fuel cell power plant; and a control system, to start up and shut down the plant and to control the load. In addition, a bottoming cycle system is added when high-temperature fuel cells (molten carbonate cells, solid electrolyte cells) are used.

2. Commercial Applications

Fuel cell systems intended for use in commercial applications will be introduced by individual users for independent energy generation; the electric energy and heat generated by the fuel cell plant will both be used (co-generation). Such systems with power generation capacities ranging from 10 kW to 200 kW or even larger, are expected to come into widespread use in future.

These fuel cell power plants are in use in hotels, hospitals, restaurants, office buildings and other locations where substantial heat demand exists. As the demand for heat utilization in cogeneration systems will also depend on the local climate, it is expected that such systems will have more opportunity for adoption in areas where there is a greater demand for thermal (heat) energy. From the point of view of total energy efficiency, when cogeneration equipment with relatively low electric power generation efficiency is used in regions where existing electric power grids are stable and highly reliable, the combination of commercial electric power and electrical heat pumps may be more efficient than cogeneration systems.

In cases where the quality of electric power provided by an existing utility grid is poor, with greater chances of voltage fluctuations and power outages, the introduction of fuel cells is conceivable in applications for office buildings equipped with computers and other information and communication equipment using electronic media.

Also, since fuel cells themselves generate DC (direct-current) power, it may be suitable to use them directly as power sources for such electronic devices driven by DC power, thus avoiding conversion loss by DC-AC converters. In this way, such plants can provide power of quality equivalent to that of the un-interruptible power supplies widely used as sources of power for computers and other equipment, with their stabilized voltages and frequencies.

3. Distributed Regional Installations

For reasons, such as the need to use land efficiently, and considerations of scenery and disaster prevention, plans are being developed for district heating and cooling plants; and fuel cells are also being considered for use in such regional facilities. There is high demand for thermal energy for heating and cooling in urban areas. In such plants, thermal energy is supplied in forms such as steam, hot water or cool water, through pipes from a heat supply plant to buildings and facilities in the supply area. Hence, in application for cogeneration systems, the waste heat from fuel cells can be utilized, thus enabling an improved energy utilization efficiency; i.e., the overall energy efficiency may climb as high as around 80%.

In order to determine the effect of cogeneration upon the introduction of such systems, analysis is necessary, based on expected heat and power demand patterns at a specific site. In general, the difference between the amount of heat that can be supplied by cogeneration systems and the amount of heat that can be utilized on the demand side must be clarified first to evaluate efficiency. The degree of waste heat utilization changes annually and daily. It also depends on how easy it is to utilize the waste heat, including the temperature of the waste heat and the form in which it is supplied. Of course, initial investment and running costs are also important factors when making a decision on introducing such systems.

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Biographical Sketches

Akifusa Hagiwara was born in 1954 and received his master's degree in mechanical engineering from Waseda University, Japan, in 1979. He joined the International Flame Research Foundation in the Netherlands in 1981, and engaged in the research projects in combustion engineering and applied fluid dynamics. Since 1987, he has been employed by the Tokyo Electric Power Company, and is involved in the fuel cell R&D activities. Currently, he is acting as Manager and Senior Researcher of Material Science Group in the Energy and Environment R&D Center.

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