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PAFC operating performance verified by Japanese gas utilities

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Abstract

Japanese gas utilities have been conducting demonstration and field tests of on-site PAFC power generation plants for more than two decades since Tokyo Gas and Osaka Gas first participated in the TARGET Program launched in the US in 1967. Total capacity of plants installed and tested to date has amounted to 15.56 MW. Cumulative number of installed plants has reached a total of 106. As of the end of August 1999, totalled 45 plants with a total capacity of 7800 kW are in operational. During the recent 2 years since the last Grove Symposium, 11 plants (three for Tokyo Gas and eight for Osaka Gas) surpassed the 40,000 h durability target set as the R,D&D target for fuel cell technology. To date, two plants have logged an uninterrupted run of over a full year, the other target set as the reliability index.

Keywords: PAFC power plant; Track record; Reliability; Durability

1. Introduction

Japanese gas utilities have been committed in addressing the energy- and environment-related issues particular to Japan through promotion of natural gas, an energy source friendly to the environment. Well before the recent public awareness of environmental issues, that is, increasing importance in the prevention of climate change, they first recognized certain advantages in favour of fuel cells, such as contributing to energy conservation as well as reduction of harmful air-borne pollutants such as NO_x and SO_x, and long-term active efforts in verifying the performance of PAFC technologies have been made to realize the market introduction of on-site PAFC power plants.

In mid-June of 1998, a committee report on the outlook for long-term energy demand and supply in Japan was submitted to MITI (Japan's Ministry of International Trade and Industry), pointed out was the increasing significant role of fuel cells as one of the promising new energy sources; the year of 2010 target figure for market introduction has been set at a rather higher level as 2200 MW. Although the track record of PAFC installations remains at levels around 2% of the target, a set of field-proven performance is thought to be useful in accelerating the market entry of on-site PAFCs.

The present short note outlines long-term demonstration and field testing activities carried out by Japanese gas utilities.

2. Track record of PAFC installation and operation

2.1. PAFC installation

Table 1 summarizes the overall PAFC plants installations in Japan by gas and electric utilities as well as other industries. As of August 1999, totalled 180 plants with a total rated power of 46.26 MW were installed. Among

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Table 1
Overall PAFC installation in Japan (as of August 1999)

Rated kilowatt year	12.5	40	50	100	200	500	> 1000	Unit	Capacity (kW)
73	4							4	50
82		3[a]						3	110
83							4.5 M	1	4500
84		2						2	80
87			1	1	2[c]			4	570
88					1		1 M × 2	3	2200
89				1	3			4	700
90			3	2[b]	1			6	530
91			11				11 M	12	11,550
92			21	3	8			32	2950
93			15	9	11[d]	1		36	4320
94			2	3	10	2		17	3400
95			4		5		1 M, 5 M	11	7200
96			3	1	9			13	2050
97					10			10	2000
98			1		10			11	2050
99				2	9			11	2000
Unit	4	5	61	22	79	3	6	180	
Capacity	50	190	3050	2180	15,790	1500	23.5 M		46,260

[a] 30 kW × 1.
[b] 80 kW × 1.
[c] 220 kW × 1.
[d] 170 kW × 1.

these plants, 106 plants with 15.56 MW were installed by gas utilities; 36 plants (4705 kW) for Tokyo Gas, 58 (8405 kW) for Osaka Gas, 9 (1200 kW) for Toho Gas, 2 (250 kW) for Saibu Gas, and the remaining one, 1 MW plant, for PAFC Technology Research Association. The 1 MW on-site plant was designed, constructed and run by the above-mentioned four gas companies jointly with NEDO receiving a 50% subsidy from MITI.

Apart from the gas industry, other installations have been sited in breweries, water and sewage works, electrolyser plant and at Epson's Nagano Works.

2.2. PAFC operation

Table 2 shows track record of PAFC plants currently being operated by gas utilities, in which several plants, including those which ceased operation during the first half of this year, are given.

As is apparent from these tables, 11 plants (three for Tokyo Gas and eight for Osaka Gas) surpassed the primary goal in cumulative operation time of 40,000 h, that is, the durability target set as the development target for fuel cell technology. Furthermore, Tokyo Gas is currently running two plants, Osaka Gas one and Toho Gas three plants that have topped 30,000 h mark. To date, two plants for Tokyo Gas operated continuously for more than a full year (8760 h) without a shutdown, the other target set as the reliability index. Such a long-term uninterrupted run is thought to permit a reliable operation of fuel cell plant with a minimal amount of maintenance, and that, drawing up a schedule.

It is, however, to be kept in mind that the operating performance of PAFCs of the latest market ready models, that is, those incorporate system modifications which simplify the power plant configuration, reduce size and manufacturing cost, must further be verified. In certain plants, both durability and reliability must further be improved.

Issues concerning grid connectibility and emissions are well documented, but it is noteworthy that all plants achieving 40,000 h of operation have exhibited NO_x levels < 5 ppm.

2.3. Market introduction

The above-mentioned track record of PAFCs is thought to thoroughly indicate that PAFC technology has already reached sufficient technical maturity and become market-ready. Despite such efforts by gas utilities over a long term of years to verify, and thereby to deploy on-site PAFC plants into the market, PAFCs have still been positioned as being near to the market and has not yet been accepted as a part of new energy sources for the coming generation. An assignable cause must include not comparably priced products as compared with contending conventional state-of-the-art co-generation systems as gas-engine driven co-generation units etc. Another cause includes that cell stack durability of those plants produced under the cost-cutting strategy needs further and again to be proven. Improved

Table 2
PAFCs running by Japanese gas utilities (as of August 31, 1999)
TG: Tokyo Gas; OG: Osaka Gas; THG: Toho Gas; SG: Saibu Gas; FP: Fuji; PC: ONSI; MP: Mitsubishi; TFC: Toshiba.

Installed by	Site	Model	Operation period		Running hour	Longest cont. run
			Start	End		
TG01[b]	Itabashi Eco-Polis Center	FP50D	March 1995	March 1999	29,807	3623
TG02[b]	TG Sports Center Akabane	FP50E	June 1998		9625	4098
TG03	TG Tamachi Labo	PC25A	November 1992		44,699	5997
TG04	TG Tamachi Labo	PC25A	October 1993		36,816	4003
TG05[b]	Tokyo East 21	PC25A	November 1992	February 1999	40,400	9500
TG06	TG Sodegaura LNG Terminal	PC25A	June 1993		39,912	8489
TG07	TG Senju R&D Center	PC25A	December 1992		40,990	4849
TG08[b]	Tokyo Metro. Envi. Technol. Inst.	PC25A	May 1995		28,522	9478
TG09[b]	Tokyo Metro. Misono Water Works	PC25C	May 1996		23,490	2260
TG10	TG Tamachi Labo	PC25C	June 1996		17,814	1849
TG11	TG Tamachi Labo	PC25C	June 1997		11,668	2303
TG12	TG Sodegaura LNG Terminal	PC25C	December 1996		19,661	2754
TG13[b]	NTT	PC25C	June 1998		9511	1685
TG14[b]	Tachikawa DHC	PC25C	June 1998		9580	1869
TG15[b]	TG Museum Envi. and Energy	PC25C	July 1998		8447	5596
TG16[b]	Tokyo Metro. Inst. Technology	PC25C	April 1999		3243	972
PAFCRA	TG Tamachi Labo	TFC1000	May 1995	February 1998	15,547	4102
OG01	OG Torishima FC Center	FP50	April 1992		21,503	2656
OG02[b]	UNEP Environmental Tech. Center	FP50	September 1993		41,339	3498
OG03	RITE	FP50	October 1993		43,470	6433
OG04	CO-OP Himeji Shirahama	FP100	May 1993	January 1999	41,816	4821
OG05	OG NEXT 21	FP100	September 1993	May 1999	40,065	6976
OG06	MYCAL BORE SANDA	FP100	December 1993	February 1999	38,315	4415
OG07	OG Himeji Works	FP100	January 1994		22,730	3019
OG08[b]	OG Torishima FC Center	FP100	September 1998		4367	1353
OG09[b]	CO-OP Himeji Shirahama 2	FP100E	March 1999		4207	3726
OG10[b]	Umeda Center Build.	PC25A	October 1992	May 1999	45,010	5476
OG11[b]	Sumitomo Chemical Ind., Osaka Works	PC25A	June 1993		41,473	5880
OG12	Ohtsu Tire and Rubber	PC25A	June 1993	January 1999	41,577	3224
OG13[b]	Matsushita Electric Industrial Works	PC25A	December 1993		41,850	4836
OG14[b]	Osaka Red-Cross Hospital	PC25A	October 1994		35,083	4127
OG15[b]	Nisshin Steel, Sakai Works	TFC200	June 1995		28,586	5332
OG16	NTT Osaka Hospital	TFC200	July 1996		25,553	4079
OG17	OG Torishima FC Center	PC25C	March 1996		18,699	2688
OG18	Osaka National Research Inst. (OGFCC)	PC25C	October 1996		11,624	1197
OG19	Kyoto Research Park	PC25C	March 1997		19,793	6257
OG20	Asia and Pacific Trade Center (OGFCC)	PC25C	March 1997		13,410	3601
OG21[b]	OG Semboku Works	PC25C	March 1998		11,519	4342
OG22[b]	RITE 2	PC25C	May 1998		10,970	5528
OG23[b]	Umeda Center Build.	PC25C	June 1998		9276	3850
OG24	Ohtsu Tire and Rubber (OGFCC)	PC25C	February 1999		9780	1508
OG25[b]	MYCAL BORE SANDA 2	PC25C	March 1999		4060	4060
OG26[b]	Kirin Brewery, Kyoto Plant 1	MP200	September 1995	August 1999	26,965	3503
OG27[b]	Kirin Brewery, Kyoto Plant 2	MP200	September 1995	August 1999	27,368	3522
OG28[b]	Asia Trade Center Build. 1	FP500	March 1994		20,682	4289
THG01	Howa Sports Land	FP50	June 1992		36,809	2229
THG02	The Scene Johoku	FP50	July 1996		23,993	4987
THG03[b]	Port of Nagoya Public Aquarium	FP100	June 1993		31,992	2852
THG04	TOYOTA MOTOR Honsha Plant	FP100	August 1997		14,706	2226
THG05[b]	Nagoya Sakae Washington Hotel Plaza	FP100	March 1999		4186	> 3850
THG06	THG Head Office	PC25A	November 1993		31,774	3726
THG07	DENSO Nishio Plant	PC25C	March 1997		10,573	602[a]
THG08[b]	Nagoya Univ.	PC25C	May 1998		10,295	3224
THG09[b]	TOKAI RIKA Head Office and Plant	PC25C	March 1999		4224	2237
SG01[b]	Nagasaki Huis Ten Bosch DHC	PC25C	March 1999		3735	2983

[a]: weekly start-and-stop.
[b]: 33.3% subsidized from MITI-NEDO (OG FCC): moved from OG Torishima.

cost effectiveness and operational reliability, prolonged service life as well, are thought still to be imperative.

3. Concluding remarks

Though cell stack durability of every market-ready model of plant must further be proven, the primary verification of the PAFC technology is thought now complete through a series of exhaustive efforts by Japanese gas utilities. PAFCs should be brought to the point of competitive commercialization and put on the market while they can receive subsidies from Japanese Government, 33.3% of total cost for each plant introduced by a private enterprise, while 50% introduced by a local municipality.