Joint Research on Small Binary Cycle Generation in a Sewage Treatment Plant

Year of Research	2012・2013	Establishment of energy and resource recycling

(Purpose)

The small binary cycle generation system uses waste heat with a lower heating value generated from the sewage sludge incinerator facility, which is not conventionally used as an energy source in a sewage treatment plant. The purpose of this research is to verify the electricity generation performance, the effectiveness of energy recovery, and greenhouse gas reduction when the small binary cycle generation system is applied to a sewage treatment plant, and then to create a technical manual.

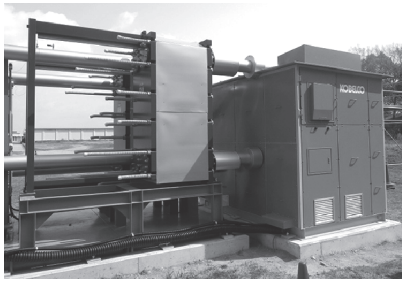

Photo 1: External view of binary cycle generation

(Results)

(1) Overview of the binary cycle generation system

The binary cycle generation system used in this experiment is shown in **Photo 1**. The maximum output of the generator is 72 kW (net amount of electricity generated is 60 kW). Incombustible inert gas HFC245fa is used for the working media, which has low boiling point of about 15°C. This makes it possible to generate electricity from the lower heating energy.

(2) Overview of verification tests

The verification tests were conducted at the bubbling fluidized bed furnace of the Kakogawa-Karyu Purification Center in Hyogo. The circulating water from the exhaust gas treatment facility (hereafter called "warm water") is used as a heat source to generate electricity, and the secondary effluent is used as cooling water.

(3) Electric power generation performance

It was confirmed that the power output at the sending end tends to be highest in winter, when the cooling water temperature is low. The performance evaluation of the generator using test results shows that the power output at the sending end (net amount of electricity generated) is approximately 36 kW when the warm water is at 80 m^3/h and 80°C and the cooling water is at 125 m^3/h and 25°C. Although the continuous operation caused scale, etc. to deposit on the heat exchanger and the pressure loss in the condenser to increase in winter, the power output at the sending end did not decrease.

(4) Corrosion resistance

We analyzed the quality of the warm water and cooling water and compared the analysis result with the water quality standards for a standard binary cycle generation system whose heat exchanger material is SUS316. The comparison result showed that many items exceeded the standard values for the specification and the stability index also showed that they tend to be corrosive. However, when we disassembled and inspected the titanium heat exchanger, after completing the verification test we did not observe any crevice corrosion or pitting as anticipated for the stainless steel; thus, we can say that the titanium heat exchanger has sufficient corrosion resistance.

(5) Benefits of implementation

An example of calculation of the benefits of implementation is shown in **Table 1**. The economic evaluation can be performed using the ratio of "B: the cost reduction from power generation for a period of 20 years" to "C: the construction cost and operation and maintenance cost for the same period of time".

Table 1: Preliminary calculations for the implemetation study

Item	Unit	Case 1	Case 2	Case 3	Remarks
Incineration capacity	(t/day)	50	100	200	
Construction cost (after government subsidy)	Million yen	21.2	21.2	40.4	2/3 of the cost is subsidized.
Operation and maintenance cost	Million yen/20 yrs	39.9	39.9	79.8	
Cost reduction from power generation	Million yen/20 yrs	-48.9	-61.6	-123.2	Electricity unit price (12 yen/kWh)
		-61.1	-77.0	-154.0	Electricity unit price (15 yen/kWh)
B/C	—	0.80	1.00	1.02	Electricity unit price (12 yen/kWh)
		1.00	1.26	1.28	Electricity unit price (15 yen/kWh)
Annual amount of electricity generated	kWh/yr	203,544	256,608	513,216	The number of operating days in a year: 330 days
CO_2 emission factor	t-CO_2/kWh	0.000525	0.000525	0.000525	Tokyo Electric Power Co. (2012)
Annual CO_2 reduction amount	t-CO_2/yr	106	134	269	

The result showed that the B/C is 1 or higher, except in Case 1 with electricity unit price of 12 yen/kWh, hence; this technology is economically feasible.

(Summary)

Using a lower heating energy, which is not conventionally used, does not have any influence on the amount of auxiliary fuel used in a sewage sludge incinerator, and can contribute to reducing electrical power consumption and the greenhouse gas that results from generating electricity through introducing this technology.

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