# Waste incineration and biogas generation complex
# – New waste treatment system compatible with the feed-in tariff scheme

*In March 2014, Kawasaki completed the construction of Japan's first waste incineration and biogas generation complex called Hofu City Clean Center. The facility converts municipal waste into biogas via a methane fermentation process. The biogas is used to superheat main boiler steam for high-efficiency power generation. Kawasaki has adopted the proprietary Parallel Flow Type Incinerator for this facility, enabling low-emission combustion with a low excess air ratio. This resulted in a system that is both energy efficient and environmentally friendly.*

## Preface

Expectations towards waste as an energy source have steadily grown in recent years based on the perspectives of global environmental conservation and energy issues, and waste incinerators and biogas generators are now attracting attention.

## 1 System overview

From the first facility Kawasaki developed, we have delivered various incineration facilities from the perspective of sanitary waste treatment, responding to the needs of the times. We have also worked to increase generation efficiency from the 1990s.

With this as a background, Kawasaki recently delivered the Hofu City Clean Center, adopting a complex of waste incineration and biogasification—the first of its kind in Japan. The combustible waste treatment facility combines our propriety waste incineration technology with biogasification technology that ferments methane from municipal waste in a complex system to realize a generation efficiency of 23.5%, the highest level for a facility of its scale. The plant also has a recycling facility.

The combustible waste treatment facility is a complex facility combining a waste incineration system and a biogasification system, which have the following capacities.

① Combustible waste treatment facility
- Waste incineration system 150 t/24h (75 t/24h × 2 furnaces)
- Biogasification system 51.5 t/24h (25.75 t/24h × 2 tanks)

② Recycling facility 23 t/5h

Figure 1 shows the treatment flow of the complex facility. Combustible municipal waste is treated according to this flow.

### (1) Waste incineration system

① Waste collected from households is stored in a waste pit, after which part of it is supplied to the incinerators for treatment. After combustion, the heat of exhaust gas is recovered by the waste heat boiler.

② The harmful substances contained in the combustion exhaust are decomposed and removed by non-catalytic denitration equipment and bag filters.

③ The bottom ash from incinerators and fly ash from bag filters are used as cement raw material.

### (2) Biogasification system

① Some of the waste stored in the waste pit is supplied to a sorting system for shredding, magnetic separation, mechanical separation, and other forms of preprocessing. The waste suitable as material for biogasification is stored in a sorted waste pit and other waste is returned to the waste pit.

② The waste in the sorted waste pit is further shredded

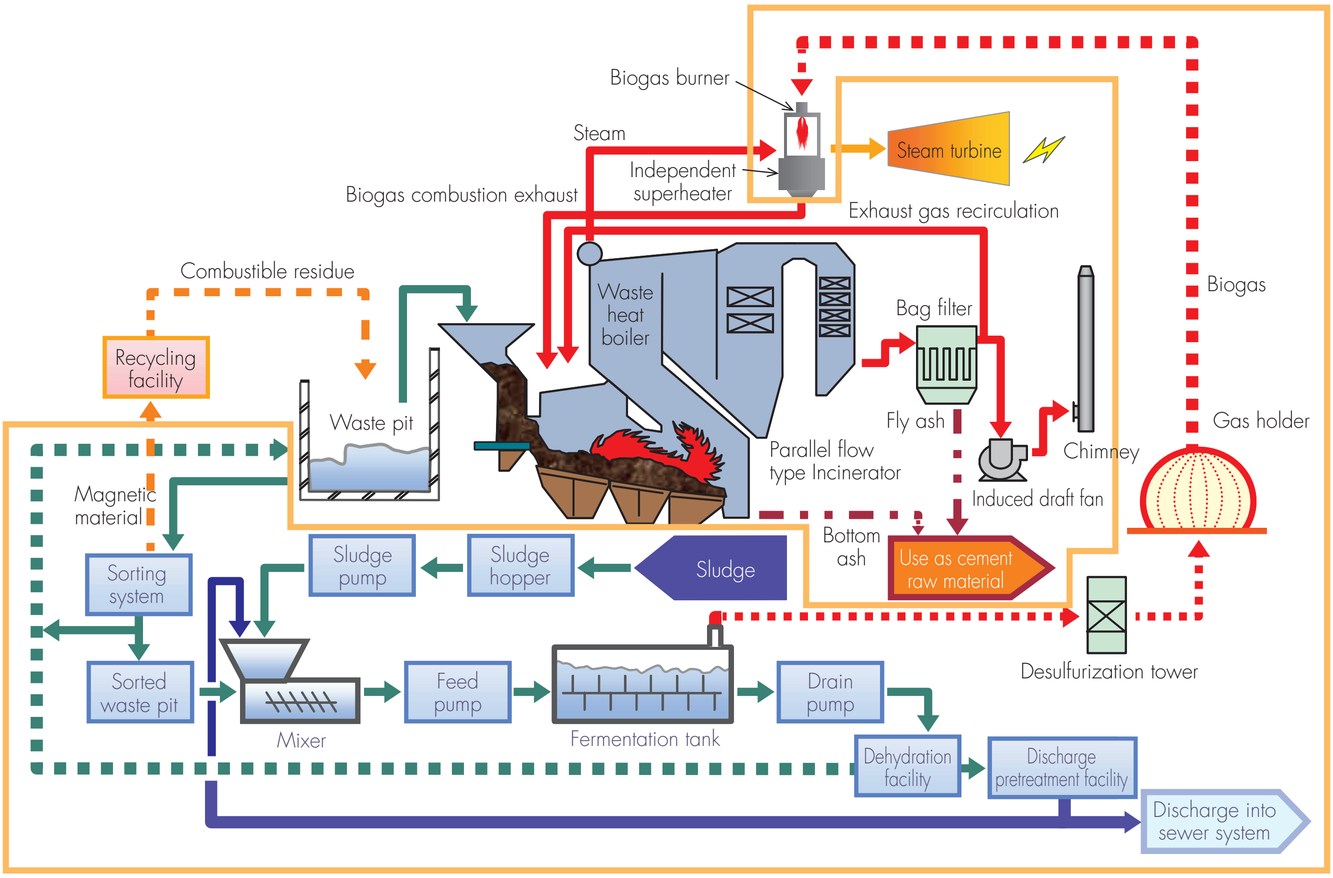


Fig. 1  Complex facility treatment flow

and mixed with dilution water and sewage sludge received from an adjoining facility. It is then made a solid concentration suitable for biogasification and fed into a fermentation tank by a feed pump.

③ Biogas including methane is generated in the fermentation tank by decomposing the organic matter in the raw material. Hydrogen sulfide is removed from the generated biogas in the desulfurization tower, after which the biogas is stored in a gas holder.

**(3) Complex**

① The fermentation residue generated in the fermentation tank of the biogasification system is dehydrated and returned to the waste pit for incineration with the waste.

② The biogas generated in the biogasification system is burned in the biogas burner and used as a heat source for an independent superheater that further superheats the steam generated by the waste heat boiler.

③ The biogas combustion exhaust from which the heat has been recovered by the independent superheater is fed into an incinerator and the heat it still retains is recovered in the waste heat boiler in order to maximize the rate of heat recovery.

## 2 Design and operation of each element

**(1) Parallel Flow Type Incinerator**

Kawasaki has adopted the proprietary Parallel Flow Type Incinerator (Fig. 2) in the facility, realizing a high energy recovery rate and low emissions through low air ratio combustion. Its properties are as follows.

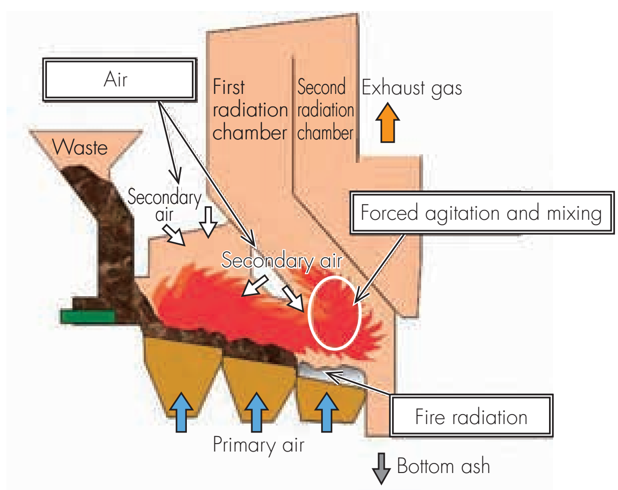


Fig. 2  Prallel Flow Type Incinerator

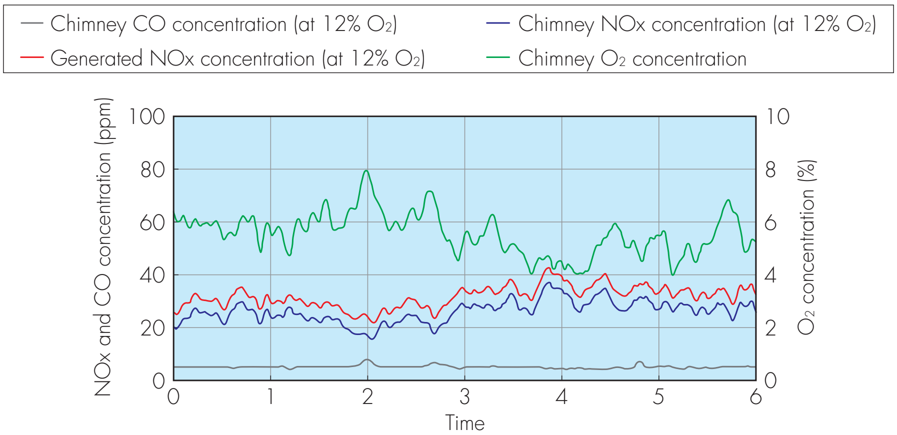


Fig. 3 Trends in exhaust gas emissions

①The form of the parallel flow reverses gas flow at the incinerator outlet, enabling efficient and low air ratio combustion due to the forced mixing and agitation of the air.

②The establishment of multiple secondary air feed points allows the introduction of suitable volumes of air at suitable nozzles, enabling decreased air intake and low air ratio combustion.

③Staged combustion with secondary air homogenizes the temperature in the furnace and eliminates isolated regions of high temperature, suppressing the generation of thermal NOx and enabling low NOx combustion.

④The structure makes fire pass through above the ash, enabling combustion by radiation heat, which can burn out combustibles.

Figure 3 shows the trends in exhaust gas emissions realized at the Hofu City Clean Center by the above design. From this the facility is found to be operating at a low air ratio and with low emissions at an average of 5.6% $O_2$ and 32 ppm NOx.

**(2) Sorting system**

It is necessary to sort the waste gathered in the facility into waste suitable for biogasification and that not suitable. In addition to decreasing the efficiency of the fermentation process, improper sorting is a cause of pipe blockage around the fermentation tank.

Sorting can be performed at the collection stage or mechanically after dumping into waste pit, and this facility adopts the latter method, which does not require waste to be presorted in each household. Figure 4 shows the flow of mechanical sorting.

The waste accepted is around 500 mm in size. This is coarsely shredded to around 150 mm by a primary

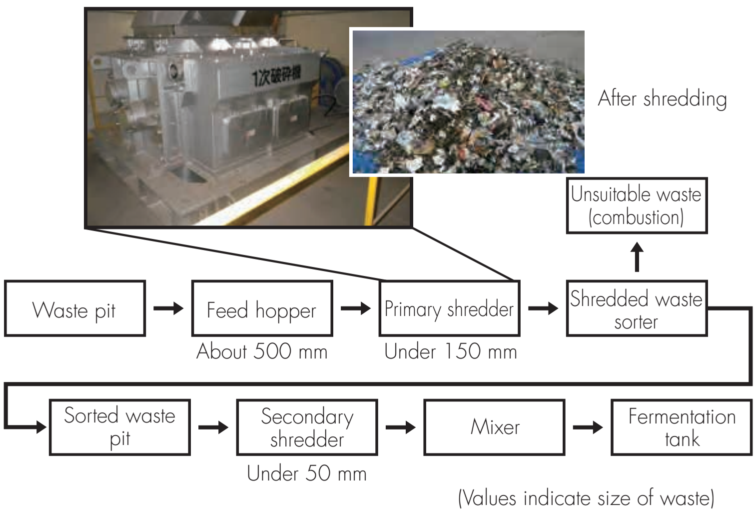


Fig. 4 Mechanical sorting flow

shredder and turned into sorted waste by mechanical sorting. This reduces the volume of large or long vinyl and cloths unsuitable for methane fermentation, and sorts the kitchen waste and paper, enabling a good fermentation material.

**(3) Methane fermentation system**

High-temperature methane fermentation is employed, in which the inside of the fermentation tank is heated to approximately 55°C to decompose the organic matter. The material remains inside the fermentation tank for around 20 days.

(i) Strength evaluations of tank

The fermentation tank is a horizontal steel-plate cylinder with a diameter of 6.8 m, length of 34 m, and volume of 1,000 $m^3$. Paddles are installed to constantly agitate the material and efficiently expel the gas generated inside the tank.

The fermentation tank needs to be strong enough to retain its contents and biogas even during an earthquake. Accordingly, Kawasaki performed an analysis of stress (Fig. 5) along with an analysis of deformation conditions during operation in the event an earthquake, and reflected the results in the strength design of the tank. The same analysis was also performed concerning deformation conditions during normal operation to verify that there are no design issues.

(ii) Operation status

The sorted waste is shredded to under 50 mm by a secondary shredder, mixed with regulating water and sludge, and fed to the fermentation tank. The system has maintained stable operation to date, indicating that this fermentation technology has a high tolerance to the inclusion of debris. Also, the system has enough capacity for stable biogasification without having municipal waste presorted in each household.

Figure 6 shows the biogas generation status. The biogas generation rate exceeds 250 $m^3$ N/ton waste, demonstrating a performance greatly surpassing the 150 $m^3$ N/ton waste, which was a condition for a 1/2 subsidy rate for a

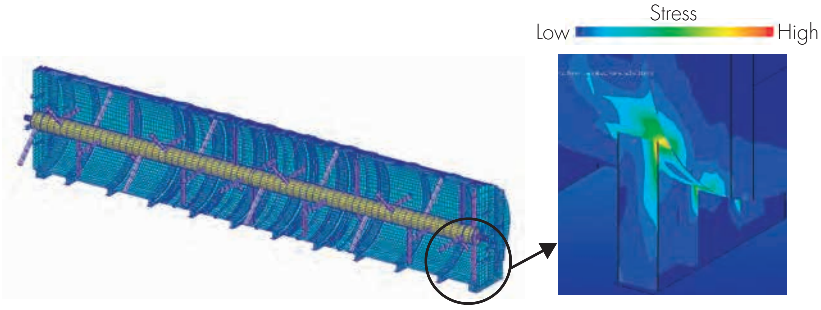


Fig. 5  Structure and stress analysis results of fermentation tank

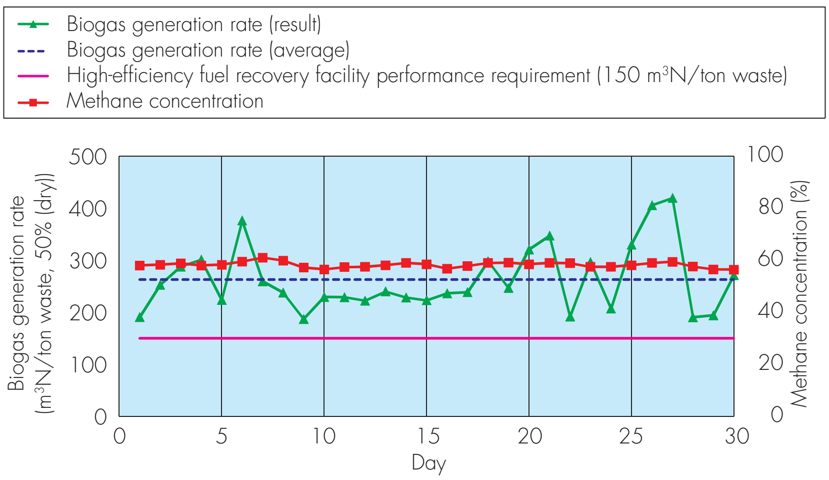


Fig. 6  Biogas generation status (December 2014)

high-efficiency fuel recovery facility. Also, the methane gas concentration was higher than the planned value of 54% at about 58% on average.

**(4) Complex of waste incineration and biogas**

At the facility, the steam condition for the waste heat boiler is 4 MPaG×365°C. However, the steam acquired by the waste heat boiler is further superheated to 415°C by the independent superheater (Fig. 7) using the high-temperature gas obtained by burning the biogas.

(i) Operation of the independent superheater

Figure 8 shows the operating status of the biogas burner and independent superheater. In the graph, "Before superheating by biogas" indicates the main steam temperature at the boiler outlet and "After superheating" indicates the main steam temperature at the independent superheater outlet.

It was possible to stably superheat the main steam with the load of biogas burner at 100% and at 50% of its rated value. A stepped change was implemented at about 20 hours, but the load following was extremely quick and operational adjustments were verified to be simple.

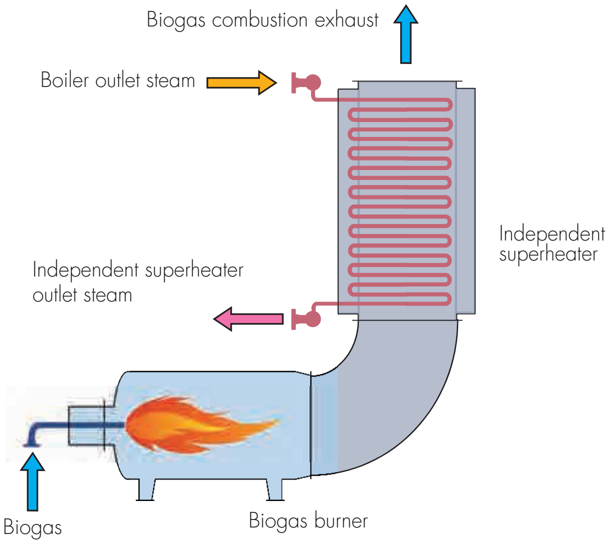


Fig. 7 Independent superheater

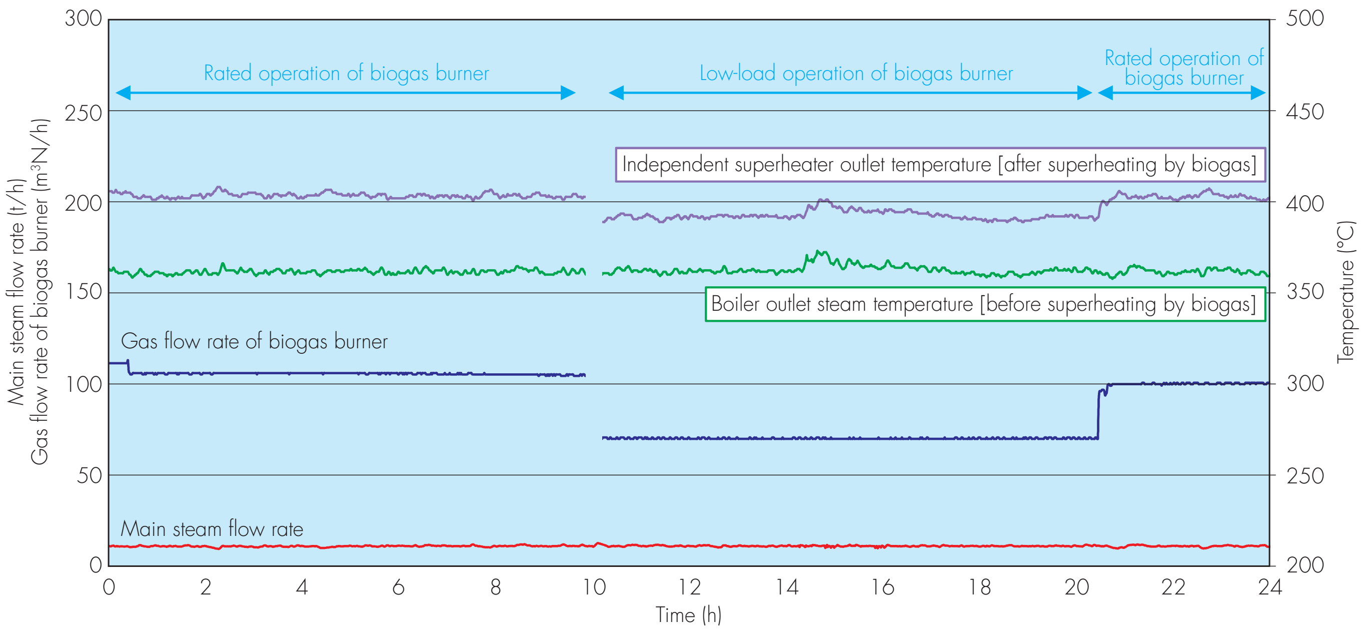


Fig. 8 Operating status of biogas burner and independent superheater

Table 1  Power generation efficiency

| Independent superheater | During operation | During suspension |
|---|---|---|
| Power generation (KWh) | 3,545 | 3,584 |
| Waste heat input (MJ/h) | 62,429 | 63,202 |
| Biogas heat input (MJ/h) | 3,885 | 0 |
| Generation efficiency (%) | 23.6 | 21.0 |

(ii) Improvement of power generation efficiency

In a comparison of power generation efficiency when the biogas burner is in operation and when it is suspended, an improvement of over 2% in efficiency was achieved (Table 1).

## Concluding remarks

This complex system equipped with an independent superheater fueled by biogas can contribute to the improvement of power generation efficiency in comparison to a simple waste incineration power generation facility of the same scale. Furthermore, the system is approved for the feed-in tariff. Moving forward, Kawasaki intends to promote complex system using an independent superheater, which is a simple system providing both ease of operational adjustment and simple maintenance.


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