



Highly Efficient Internal Circulation Fluidized Bed-type Boiler

Feature Report—Environmental Business

Recycle Power Generation Technology

Capable of both refuse disposal and resource conservation by burning domestic garbage and industrial wastes as fuel, recycle power generation plants are being introduced at various locations throughout Japan. The total output of these plants reached the 1,000,000 kW level in FY2002. For use to become more common, this technology needs to be further developed.

Kawasaki has been working on power generation plants that burn various types of refuse and industrial waste as fuel, addressing the challenges of recycle power generation. In FY2002, we made great achievements as evidenced by the installment of Japan's largest RDF power generation plant, and advances in our efforts to develop efficient woody biomass burning power generation plants.

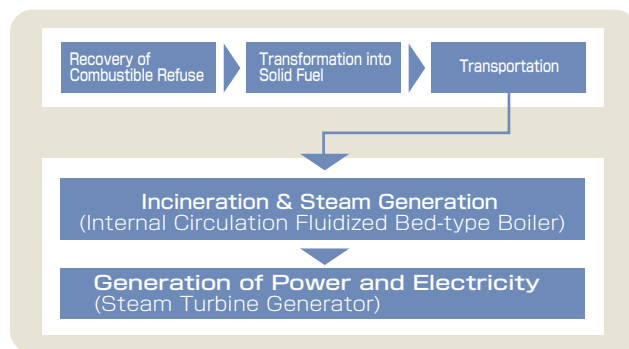
Product Introduction: Largest RDF (Refuse Derived Fuel) Power Generation Plant in Japan

● Control of dioxins by centralized refuse disposal, and RDF power generation

The RDF power generation generates electric power by burning a unique solid fuel (RDF) that is prepared by drying and reducing the volume of combustible refuses. One outstanding advantage of RDF power generation is that RDF is easy to transport and store compared to ordinary refuse. Another more important advantage is the capability of reliable dioxin control because smaller incinerators distributed in various municipalities, where dioxin control was very difficult, have been merged into a centralized large RDF power generation plant.

Currently, RDF power generation plants are operated at three locations in Japan to generate a total of 39,600 kW. In January 2003, in Japan's first regional environmental program, the Omuta Recycle Power Plant was commissioned with the sponsorship of many local governments. Kawasaki also took part in this program, providing Japan's largest RDF power generation plant.

[Schematic for RDF Electric Power Generation]



● Kawasaki employs a unique Internal Circulation Fluidized Bed-type Boiler with efficiency that is comparable to coal-burning boiler.

When refuse containing chlorine burns, a highly corrosive gas (hydrogen chloride) occurs. To prevent premature corrosion of the heat exchange tube by hydrogen chloride, the temperature in the heat exchange area needs to be limited. As a result, the steam obtained with conventional refuse burning power generation plant was limited to approx. 20 atm and 300°C, and the power-generation efficiency with the conventional plant was limited to approx. 20%.

To address this problem, Kawasaki has employed a fluidized-bed system and has developed a unique construction that can prevent corrosion of the heat exchange tube even at high temperatures by placing the heat exchange tube in an area that is relatively free

from hydrogen chloride. Since 1996, we have conducted demonstration tests on an experimental basis, and have developed proprietary technology for a highly efficient Internal Circulation Fluidized Bed-type Boiler.

Thanks to this technology, the boiler of the Omuta Recycle Power Plant succeeded in stably generating 83 atm and 503°C steam. The amount of RDF burnt a day reaches 315 t and the rated amount of generation is 20,600 kW. The power-generation efficiency with this system is 30% or higher, which is comparable with coal-burning thermal power generation.

● Kawasaki has established its own expertise in RDF processing plant.

Kawasaki is working in cooperation with Electric Power Development Co., Ltd. and Kitakyushu City to conduct test operations and developing a unique RDF processing plant.

For the RDF power generation project in Omuta, Kawasaki provided, together with other manufacturers, one of Japan's largest RDF processing plants (amount of refuse treated: 225 t/day, RDF production capacity: 122 t/day) to the Omuta/Arao Sanitation Union.

※The Omuta Recycle Power Plant is run by the Omuta Recycle Power Co., Ltd., which was founded and is financed by Fukuoka Prefecture, Electric Power Development Co., Ltd., etc. and 28 associated local governments, including Omuta City, in Fukuoka and Kumamoto prefectures. A total of seven cooperatives serving these 28 municipalities in Fukuoka and Kumamoto prefectures take part in RDF processing. Each cooperative transforms refuse collected in its area into RDF and transports the obtained RDF to the Omuta Recycle Power Plant.

○RDF production

The RDF used to fuel RDF power generation in Omuta is manufactured using domestic refuse from the region. The collected domestic refuse is first crushed to sizes suitable for drying, then dried with hot air blasts obtained by burning kerosene, then non-combustible matters such as steel, aluminum and glass are removed from the refuse. These separated materials are recycled. Next, the refuse is further pulverized, an antiseptic agent is added, and it is formed into RDF.



RDF forming machine and RDF

○Benefits of RDF

- RDF features a high density, because it is formed by compression, so it is conveniently stored and transported.
- RDF does not emit odor or putrefy, due to the drying and compression in the forming process and the addition of an antiseptic agent, and therefore it can be stored for an extended period.
- Uniform quality ensures good burning performance.

Product Introduction: Japan's First RPF (Refuse Paper & Plastic Fuel) Burning Waste Power Generation Plant

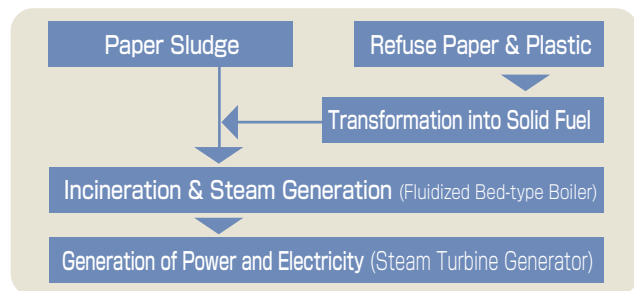
● Recycle power generation by burning used paper and waste plastic materials as fuel

RPF, which is a solid fuel derived from used paper and waste plastic, can be used as an auxiliary fuel for waste power generation that burns paper sludge.

Waste power generation plant delivered in December 2002 burns RPF and paper sludge in the fluidized bed-type boiler and attains a power-generation efficiency of 25.7%. It generates 10,000 kW of

electricity with steam generated at a rate of 50 t/h. Unlike conventional waste power generation plants, this plant burns paper sludge and RPF only rather than using fossil fuels, contributing to the reduction of CO₂ emission.

[Schematic for RPF Electric Power Generation]



RPF burning waste power generation plant
The capacity is one of the largest in Japan, burning 330 t/day of paper sludge and 50 t/day of RPF.

Product Introduction: Biogas Burning Power Generation Plant

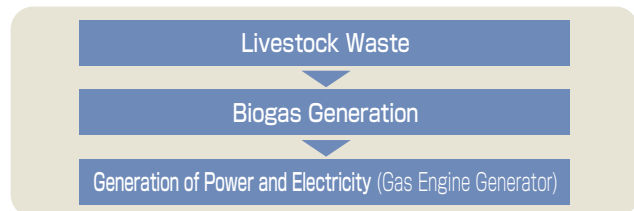
● Recycle power generation using livestock waste

A regulation on livestock waste left on fields is going to be imposed in the near future. To address this issue, Kawasaki is developing a biogas power generation plant that uses livestock waste-derived methane as fuel. We imported the technology for a methane fermentation tank within the biogas generation section. In Yubetsu-cho and Shimizu-cho, Hokkaido, we constructed biogas power generation plants that are currently operating on a commercial basis.

We will continue to run these plants, situated in the cold climate

of northern Japan where stable operation of biogas power generation plant is usually difficult, and work to develop the technology for economical biogas power generation plant that is suitable to Japan's climate.

[Schematic for Biogas Burning Power Generation]



Biogas power generation plant in Yubetsu-cho

Product Introduction: Woody Biomass Power Generation Plant

● Recycle power generation using waste wood and logs from forest thinning

Direct Burning—Steam Turbine System

This system generates electric power by driving a turbine with steam generated by burning woody biomass, and is suitable for applications that need both electricity and heat. In November 2003, 600 kW plant will be completed in Shirakawa-cho, Gifu Prefecture.

Pressurized Fluidized Bed Gasification—Gas Turbine System

Woody biomass is gasified in a pressurized fluidized bed gasifier, and the obtained combustible gas drives a gas turbine to generate electric power. The plant is compact and features high power generation efficiency. We are now developing plant rated from 30 to 600 kW.

Fixed Bed Gasification—Gas Engine System

Woody biomass is gasified in a fixed bed gasifier, and the obtained combustible gas drives a gas engine to generate electric power. The plant is simple and easy-to-operate, and 100 kW scale demonstration plant will be completed in September 2003.



Biomass power generation plant now under construction in Shirakawa-cho, Gifu Prefecture (artist's rendition)