Contribution of Waste to Energy Technology to Global Warming

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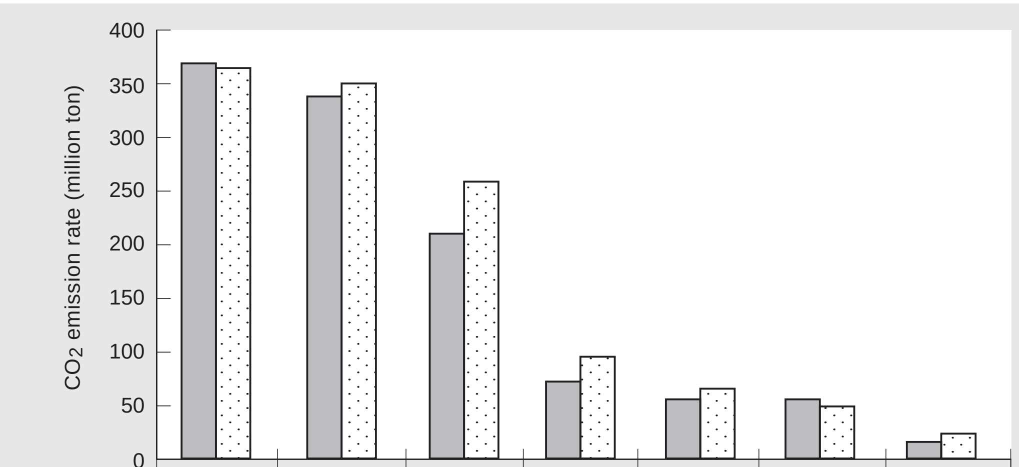
Based on the additional new energy measures in the "Guideline of Measures to prevent Global Warming," a target has been set in Japan to introduce the waste-to-energy generation amounting to 4.17 million kW by the year 2010. This report describes the waste-to-energy technologies of Mitsubishi Heavy Industries (MHI) in correspondence with the aforesaid measures. The report particularly gives an outline of the activities and achievements of MHI in the improvements of power generation efficiency through high-temperature and high-pressure boiler for waste-to-energy generation, the improvements in heat recovery efficiency through oxygen-enriched combustion system of the next-generation stoker incinerator, the prevention of nitrous oxide generation, reduction of power consumption in plasma ash melting furnace, etc. together with the contribution of MHI waste-to-energy technologies to global warming countermeasures.

1. Introduction

Based on the "United Nations Framework Convention for Climate Change" enforced in March 1994, the "Kyoto Protocol" stipulating for legal undertakings regarding the reduction of greenhouse effect gasses such as carbon dioxide and others, was adopted in December 1997. The Kyoto Protocol precisely sets the target levels of reduction of the emission of greenhouse effect gasses for the advanced countries, and calls for efforts to reduce the total emission of greenhouse gasses in order to achieve the set target[(1)].

Figure 1 shows the changes in CO_2 emission per field in Japan for 1990 and 2001. Compared with other fields, the waste field has the emission rate itself low, but as compared with the emission level of 1990, the emission rate has been increased by 40% because of increase in the consumption rate of plastic, etc. In order to reduce the CO_2 emission in waste field, it is essential to prevent the generation of waste itself and to reduce the volume of incineration through promotion of recycling. However, in spite of the efforts made for high efficiency through energy-saving and resource-saving, it is impossible to prevent the generation of waste itself, so that it is important to take the waste as a useful fuel and to restore it as an effective energy.



	Industry	Energy conversion	Trans-portation	General business	Household	Industrial process	Waste
1990	369	339	211	73	57	57	17
2001	366	351	260	96	66	51	25

Fig. 1 Change in CO_2 emission rate per field
CO_2 emission rate itself for the waste field is low but shows an upward trend.

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Hence, introduction of waste-to-energy plant of 4.17 million kW by the year 2010 was set as one of the targets as an additional new energy countermeasure in the "Guideline of Measures to prevent Global Warming," concluded by the "Global Warming Prevention Headquarters" in March 2002.

This report throws light in the trends of waste-to-energy technologies and describes MHI technologies contributing to the countermeasures against global warming.

2. Improvement in waste-to-energy generation efficiency

In introducing the waste-to-energy, it is necessary to increase the waste-to-energy facilities, and to improve the waste-to-energy generation efficiency. MHI is actively engaged not only in the construction of waste-to-energy facilities but also in the improvement of waste-to-energy efficiency. **Figure 2** shows the changes in steam temperatures in the boiler for municipal solid wastes (MSW) incinerators[(2)]. In Japan 3 MPa, 570 K class (30 kg/cm^2, 300^{o}C class) boilers were mainly used until the early 1990's, which are currently replaced with 4 MPa, 670 K class (40 kg/cm^2, 400^{o}C class) boilers, with the boilers of higher pressure and higher temperature expected to come in the future.

The MSW incineration boilers had the steam conditions kept to lower levels because of the chlorine, etc. contained in the municipal solid wastes caused the acidic gasses such as hydrogen chloride gas, etc. to generate in the combustion flue gas, leading to corrosion of boiler tubes, particularly the super heater tube. As a result power generation efficiency by incineration of municipal solid wastes was confined to approximately a dozen percentage over a long time period. However, thanks to the prompt developments made on the anti-corrosive steel tubes for boiler super heaters, the efficiency has been improved to over 20%.

MHI put the 4 MPa, 670 K class boilers in practical use for the exports starting from 1986, is now constructing a 6.5 MPa, 723 K class MSW incinerator in China, and has outstanding records of manufacturing top-level MSW incineration power generation boilers over the 4 MPa, 670 K class in Japan.

MHI has been in charge of the development of elemental technologies such as high-efficiency stoker incinerator, corrosion-resistant super heater, etc. in the project of "Development of High-efficiency Waste-to-energy Technology by New Energy and Industrial Technology Development Organization (NEDO)" since 1991, and successfully constructed a plant equipped with a high-temperature, high-pressure boiler of 10 MPa, 770 K class (100 kg/cm^2, 500^{o}C class) for the first time in the world in 1998, which is currently operated smoothly.

Figure 3 shows the structures of 4 MPa, 670 K class boiler, the main boiler currently in use, and the high-level 10 MPa, 770 K class boiler. The 4 MPa 670 K class boiler is equipped with radiation heating surface to ensure adequate retention for the combustion gas in pass no.1 for ascending flow and pass no.2 for descending flow, with the super heater installed at pass no.3. The 10 MPa, 770 K class boiler, on the other hand, has the tertiary super heater installed at pass no.3, with the combustion gas temperature around this area kept to 650^{o}C or under. As for the materials of super heaters, the primary super heater is made of carbon steel, the secondary one of stainless steel and the tertiary one of high-alloy steel.

The photograph at the top of the first page shows the MSW incineration power generation plant, the largest in the world, built by MHI in Singapore. The plant, composed of 720 t/day × 6 incinerators, is capable of treating 4 320 t of municipal solid wastes per day and is equipped with 3.7 MPa, 643 K boiler, with the rated power 132 600 kW generated from 2000. The plant is currently operating normally.

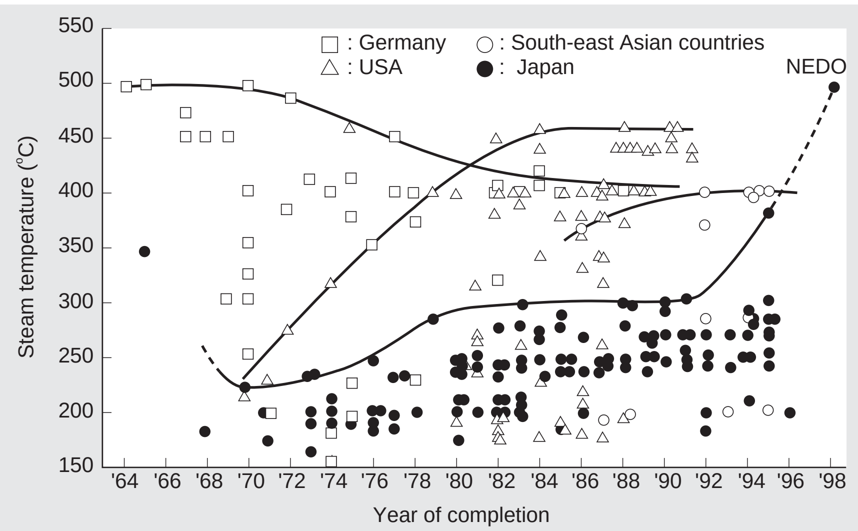

Fig. 2 Change in steam temperature of boiler for waste-to-energy generation
4 MPa, 670 K class boilers are mainly used these days, with the tendency increased for high-temperature and high-pressure boilers.

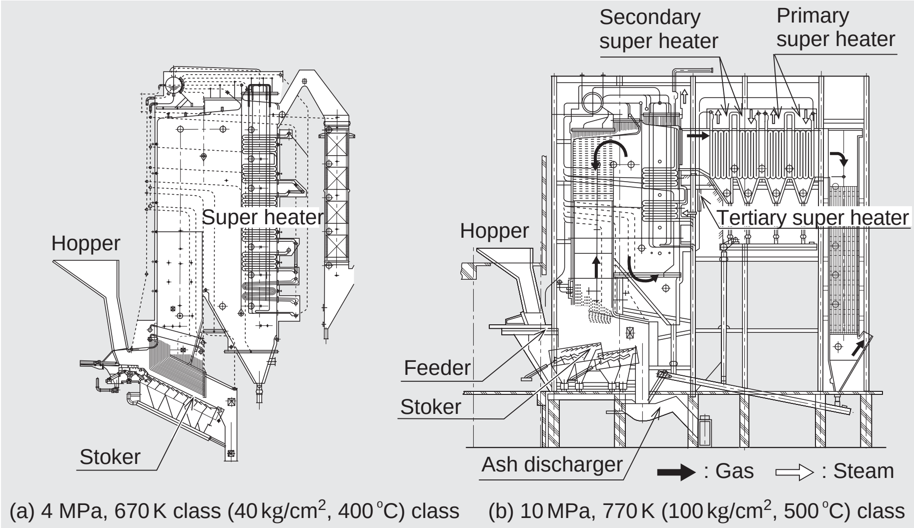

Fig. 3 Structural diagram of high-temperature, high-pressure boiler
Structures of most commonly used 4 MPa, 670 K class boiler and the world's first 10 MPa, 770 K class boiler are shown.

3. Contribution of the next-generation stoker incinerator to countermeasures against global warming

MHI has already developed the next-generation stoker incinerator using oxygen-enriched combustion system, with commercial plants already deployed[3]. The oxygen-enriched combustion system as shown in **Fig. 4** has the features given below.

(1) Utilization of oxygen-enriched primary air promotes intense combustion of solid waste bed on the grate so that reduction of unburnt combustibles (CO, DXNs, etc) in the flue gas and improvement of ash quality is achieved.

(2) Recirculation of flue gas as secondary air improves the mixing of combustion gas in the furnace to complete gaseous combustion and prevents NOx from increasing.

(3) Substantial decrease in the flue gas flow rate allows compact design of equipment such as boilers and flue gas treatment systems.

(4) High-temperature combustion and reduction in flue gas flow rate improve the boiler heat recovery efficiency, contributing to the countermeasures against global warming.

(5) Ensures high reliability and long-term stability of operation based on the long-stored technologies in stoker incinerator combustion.

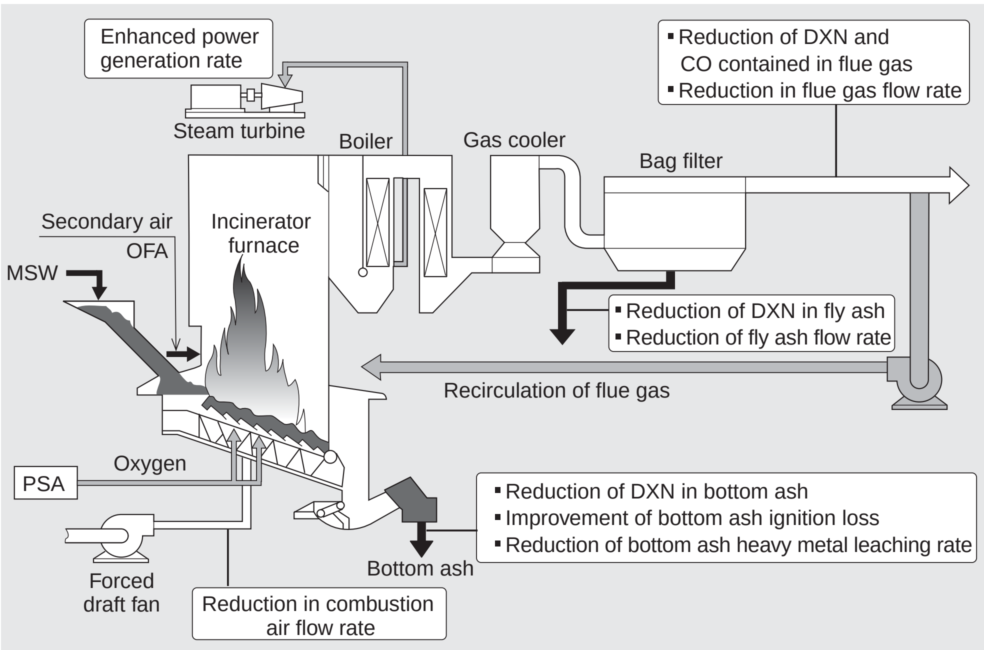

Fig. 4 Flow of "oxygen-enriched combustion system for next-generation stoker incinerator
System flow of next-generation stoker incinerator with low air ratio and high-temperature combustion due to oxygen enrichment, giving less environmental burden.

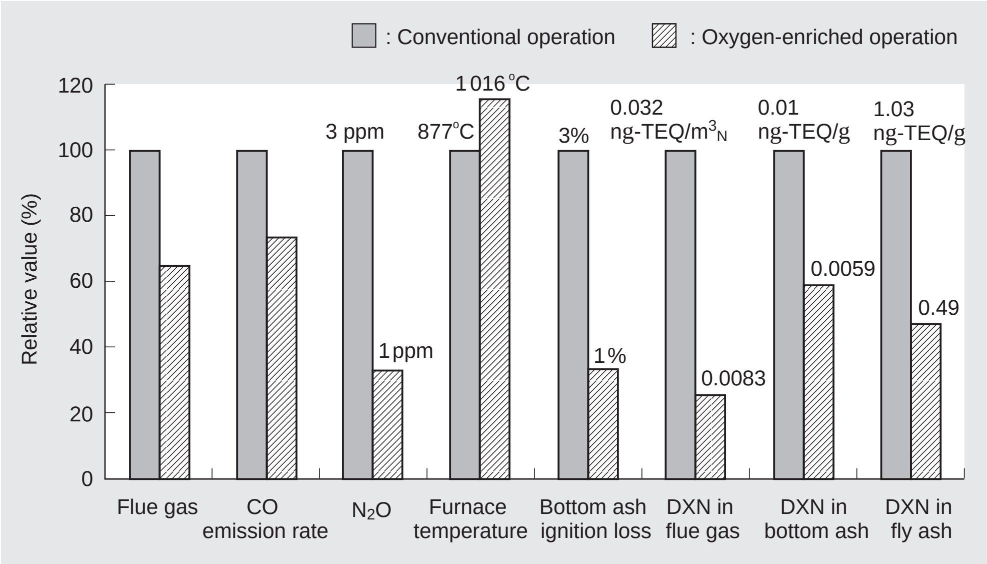

Fig. 5 Example of verification test result of oxygen-enriched combustion system
High-temperature combustion and low environmental burden have been confirmed through verification test result.

Demonstration tests have so far been conducted using commercial incinerators in Japan (146 t/day and 300 t/day incinerators) and in Germany (264 t/day incinerator) to confirm the aforesaid features as shown in **Fig. 5**. Besides, nitrous oxide with higher greenhouse effect than carbon dioxide or methane has also been drastically reduced, contributing to the countermeasures against global warming.

The first oxygen-enriched combustion system is scheduled to start operation in Austria (Arnoldstein: 256 t/day × 1 incinerator) and in Japan in 2004 (Sendai Matsumori: 200 t/day × 3 incinerators).

At present a bottom ash recirculation system without the ash melting furnace while improving the quality of the bottom ash as shown in **Fig. 6** is under development to make more effective use of the features of oxygen-enriched combustion system. When the bottom ash from a conventional waste incinerator is divided into bottom ash fine and coarse fraction, the dioxins and heavy metals get mustered to the bottom ash fine fraction, while the bottom ash coarse fraction is known to have excellent qualities. This characteristic of the bottom ash is applied to the bottom ash recirculation system. The bottom ash fine fraction with inferior qualities is recirculated to the furnace to be subjected to heat treatment under oxygen-enriched high-temperature environment. This enables the bottom ash qualities to get further improved without an ash melting furnace.

The system has been confirmed effective in improving the bottom ash qualities by constructing a small-scale pilot stoker incinerator with treating capacity 7.2 t/day and conducting combustion test[(4)].

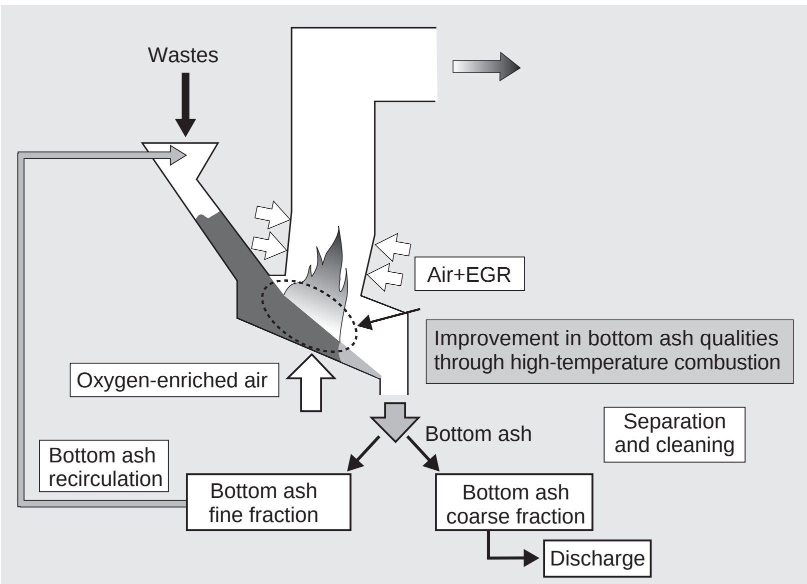

Fig. 6 Bottom ash recirculation system flow
Bottom ash fine fraction with inferior qualities is treated under high-temperature environment inside the furnace to improve the qualities.

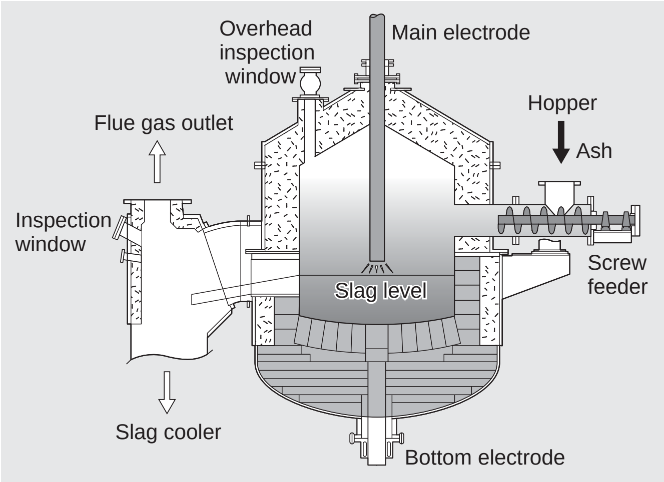

Fig. 7 Plasma ash melting furnace
Cross-sectional view of the furnace for melting ash by means of plasma

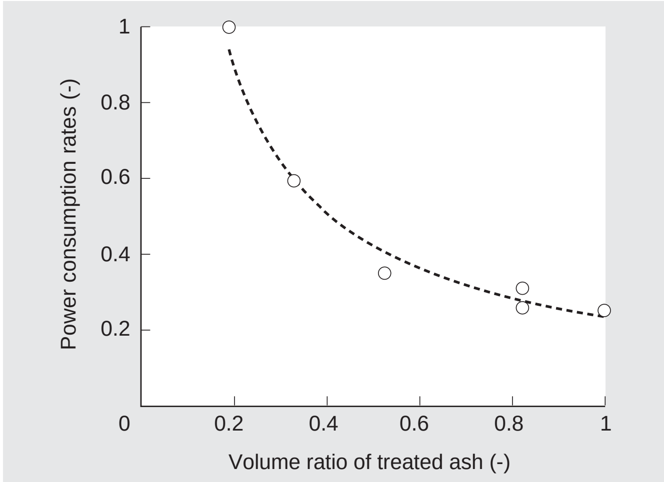

Fig. 8 Relation between treatment volume and power consumption
The increase in ash treatment volume is confirmed to reduce power consumption.

4. Reduction of power consumption in plasma ash melting furnace

In addition to the thermal recycling of the potential heat quantity of municipal solid wastes through power generation using the waste incineration as mentioned above, the ash is currently subjected to fusion and solidification for further reduction of waste in volume and to make it harmless. As a method of promoting recycling of the molten slag into road construction material, etc. the plasma ash melting furnace is widely used in recent years.

The plasma ash melting furnace whose structure is shown in **Fig. 7** melts ash by generating high-temperature plasma between main electrode (graphite) and bottom electrode, and makes use of the power generated in the MSW incinerator. The reduction in power consumption would contribute to the countermeasures against global warming.

MHI has so far succeeded in continuous operation of plasma ash melting furnace for 3 months through development of effective furnace cooling, excellent slag chute and refractory material. Further, MHI is currently engaged in the design and construction of a plant with 100 t/day × 4 plasma ash melting furnaces, the largest in size in the world, and has a record of building 10 plants in total.

With the plasma ash melting furnace becoming larger in size in recent years, the cooling and heat radiation loss rates get decreased, and the power consumption can be reduced, as shown in **Fig. 8**, which in turn is considered to contribute to the countermeasures against global warming.

5. Conclusion

This report describes the activities of MHI regarding the waste-to-energy generation with the set target level of introducing 4.17 million kW plant by the year 2010 based on the additional energy measure in the "Guideline of Measures to prevent Global Warming." The report particularly summarizes the activities and achievements for improving power generation efficiency through high-temperature and high-pressure boiler for waste incineration plants, for improving heat recovery rate through the next-generation stoker incinerator and oxygen-enriched combustion system, for preventing generation of nitrous oxide, for reducing power consumption in plasma ash melting furnace, etc.

MHI will continue to make efforts in further development of waste-to-energy technologies, hoping that MHI technologies will go a long way in contributing to the countermeasures against global warming.

References

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