Possibility of Reducing Total Dioxins Emission during Treatment of Exhaust Gas in Municipal Solid Waste Incineration (MSWI) Plants

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Introduction

The concentration of dioxins (PCDDs/PCDFs) in the exhaust gas emitted from MSWI plants was reduced to below 0.1 ng-TEQ/Nm^3 by achievement of 3-Ts and adoption of fabric filter[1]. R&D is currently underway to reduce the total dioxins emission, including those of exhaust gas, fly ash and bottom ash, from MSWI plants to below 1 μg-TEQ/ton-waste.

The spatial concentration profile of dioxins in the MSWI plant was investigated by sampling and analyzing dioxins in various points of MSWI. The following discusses the possibility of reducing total dioxins emission during exhaust gas treatment based on the findings from the profile.

Methods

The profile of dioxins was measured in the MSWI plant (Plant A). Fig. 1 shows the sampling points in a boiler. Table 1 details their locations and lists the mean temperature measured at each point.

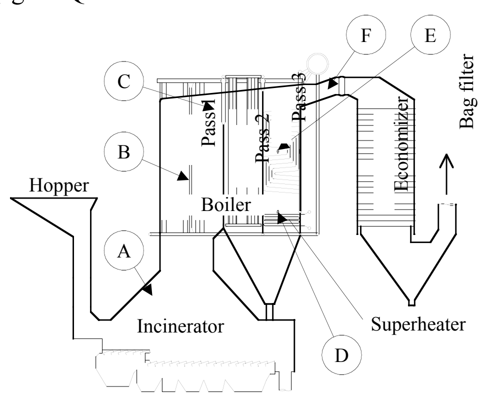

Fig. 1 Location of sampling points in boiler

Table 1 Sampling points and measured temperature

Samp. Pt.	Location	Temp.(°C)	Samp. Pt.	Location	Temp.(°C)
A	Inside incinerator	990	G	Economizer outlet	200
B	Incinerator outlet	950	H	Bag filter inlet	160
C	Outlet of Pass 1	770	I	Bag filter outlet	160
D	Superheater outlet	410	J	Bottom ash	---
E	Evaporator	320	K	Fly ash	---
F	Boiler outlet	270			

Results and Discussions

Changes up to the outlet of Pass 1

The profiles of dioxins in the exhaust gas are shown in Fig. 2. Although the dioxins concentration was high inside the incinerator, there was a rapid reduction of dioxins concentration while the exhaust gas passed through the secondary combustion chamber. Dioxins were supposed to undergo thermal decomposition, based upon the fact that each congener was reduced at similar same rates. The mean concentration of dioxins at the outlet of Pass 1 was 0.52 ng-TEQ/Nm^3. This value was the lowest in exhaust gas treatment up to the bag filter inlet.

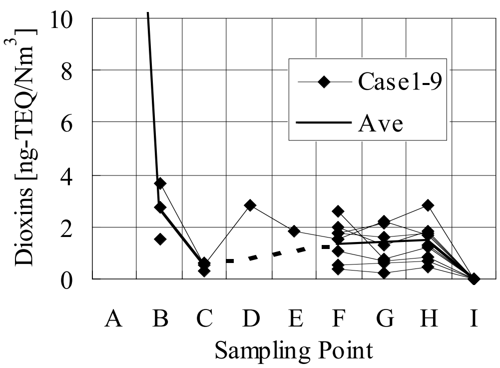

Fig. 2 The profiles of dioxins in the exhaust gas

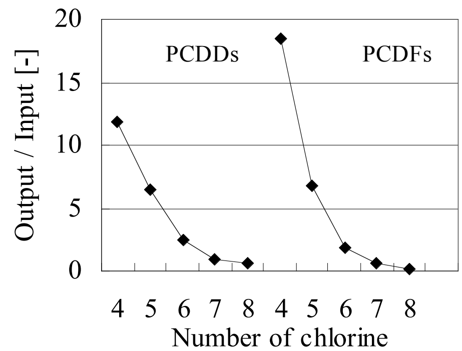

Fig. 3 The ratio of the congeners at the Superheater outlet (output) to those at the outlet of the Pass 1 (input)

Changes between the outlet of Pass and the inlet of bag filter

There was a trend for the concentration of dioxins to increase during the cooling of the exhaust gas, i.e. between the outlet of Pass 1 and the bag filter inlet. Fly ash in the exhaust gas settles down and it's concentration in the gas reduced from 1/3 to 1/5 of the original amount. The increase of dioxins concentration indicates that there were formations of dioxins at this stage.

Stieglitz et al.[2)] reported that the peaks of formation were observed at 300°C and 470°C. The former temperature was observed between the superheater outlet (D) and boiler outlet (F), and there was no increase in concentration. It was assumed that changes in concentrations could not be observed due to the reduction in dust.

The latter temperature (470°C) was observed between the outlet of Pass 1 (C) and the superheater outlet (D), and dioxins concentration increased in this zone. Fig. 3 shows the ratio of the congeners at the outlet of the superheater (output) to those of the outlet of Pass 1 (input). The figure clearly shows that there was more than a ten-fold increase for TetraCDDs and TetraCDFs, and that increase is smaller for congeners with larger chlorine numbers. Stieglitz et al. also reported that although PCDFs were formed at 470°C, there were almost no PCDDs formed at this temperature. In our experiments, however, an increase of both PCDFs and PCDDs was confirmed. This suggests that different formation mechanisms exist under the same temperature ranges.

Dioxins concentration in the exhaust gas tended to increase slightly in the region between the boiler outlet (F) and the bag filter inlet (H) where the temperature was below 270°C. Considering the reduction of dust concentration, it can be assumed that dioxins formed in this region as well. Fig. 4 shows the ratio of congener concentration at the bag filter inlet (output) to those at the boiler outlet (input). Although there was almost no change in PCDFs, there was a significant increase of O8CDDs. Such increase was less significant for congeners with smaller chlorine numbers. This implies a different formation mechanism from that for the case of 470°C.

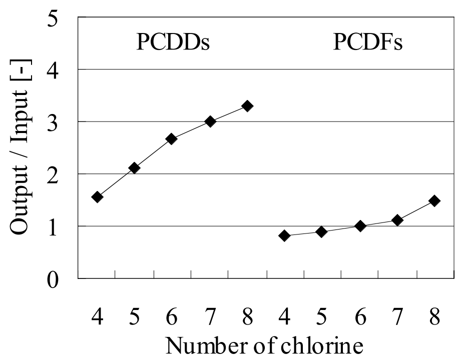

Fig. 4 The ratio of the congeners at the bag filter inlet (output) to those at the boiler outlet (input)

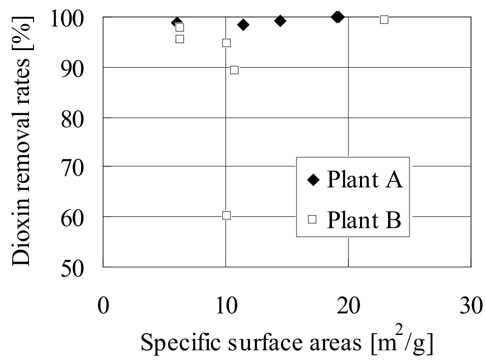

Fig. 5 The relationship between the specific surface areas of fly ash at bag filter inlets and dioxins removal rates

Removal of Dioxins by the Bag Filter

As the formation of dioxins was confirmed in all regions while the flue gas was being cooled from 770°C to 160°C, the mean concentration of dioxins at the bag filter inlet increased to 1.4 ng-TEQ/ Nm^3. The mean concentration of dioxins at the bag filter outlet was 0.007 ng-TEQ/Nm^3, indicating an efficient removal by the bag filter.

Although it is known that dioxins contained in exhaust gas of MSWI plants can be efficiently removed by fabric filters, it is also known that dioxins contained in the exhaust gas of melting furnaces cannot be removed by the same [3)]. This difference might result from the adsorption of dust. To establish a reference on adsorption, studies were conducted on the relationship between the specific surface areas of fly ash at bag filter inlet and dioxins removal rates (at MSWI plants A and B). Fig. 5 shows the results. The removal rates differed depending on the plant, regardless of same specific surface areas. The specific surface area seems to be inappropriate as an indicator of the dioxins adsorption onto fly ash.

Reduction in Total Dioxins Emission

Dioxins at the outlet of Pass 1 became low due to the achievements of 3-Ts. However, no prevention to dioxins formation could be made during the cooling of exhaust gas for heat recovery. Consequently, dioxins concentration increased at the bag filter inlet and the concentration of dioxins in fly ash was 0.28 ng-TEQ/g.

As MSWI involves not only the treatment of waste but also energy recovery, it is difficult to prevent dioxins form forming by the methods such as reducing the retention time inside the boiler or lowering the temperature of boiler.

Dioxins were readily collected by a cylindrical paper filter for sampling at the outlet of Pass 1. If the dust were removed at the outlet of Pass 1, the dioxins concentration in collected ash would be lower than 0.1 ng-TEQ/g. This indicates that the total dioxins emission could be reduced to 1 μg-TEQ/ton-waste or less.

Hunsinger[4)] have reported that dioxins formation could not be prevented by the use of high-temperature dust collector. However, if dust were removed at high temperature, the energy collection would become advantageous. We are currently studying to confirm the behavior of dioxins in the high temperature dust collector and the decomposition of dioxins at high temperature.

References

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