Reduction of Total Dioxin Emission from MSW Incinerators

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1. Introduction

The 1997 Guideline for Controlling Polychlorinated Dibenzo-p-dioxins and Dibenzofrans (PCDDs/DFs) of MSW Incinerators in Japan, Ministry of Health and Welfare, stipulates a dioxin concentration of below 0.1 ng-TEQ/m^3N for newly erected continuous operation incinerators. The same stipulates that the total dioxin emission from exhaust gas, incineration ash and fly ash is to be below 5 μg-TEQ/t-waste .

Reduction in dioxin emission was attempted by optimizing incinerator and boiler configurations, reducing dioxin generation by secondary combustion, lowering the temperature of exhaust gas during treatment, and resynthesizing control and dioxin removal by bag filter. This approach was put to use at three new facilities (built according to old Guideline: reference dioxin concentration value of below 0.5 ng-TEQ/m^3N) and the reference dioxin concentration value of below 0.1 ng-TEQ/m^3N (stipulated in the 1997 Guideline) was sufficiently achieved. Furthermore, it was found possible to achieve a reduction in total dioxin emission to below 5 μg-TEQ/t-waste (also stipulated in the 1997 Guideline) by catalytic treatment of exhaust gas and treatment of incineration ash and fly ash (melting/ solidification, thermal dechlorination, etc.). The following discusses the above and introduces new findings.

2. Analytical Method

Table 1 shows the flow and equipment of the three facilities (Facility A, B, & C) where dioxin emissions were reduced. All three facilities comprised totally continuous incinerators with boiler turbines, and were equipped with dry type, hazardous gas removal devices and bag filters. The last stage of Facility C comprised a catalytic denitrification (Selective Catalytic Reduction) process.

Facility A	140t/D × 2 furnaces B → AH → GC → BF(160°C) →
Facility B	110t/D × 3 furnaces B → ECO → BF(170°C) →
Facility C	120t/D × 2 furnaces B → ECO → GC → BF(150°C) → RGH → SCR(200°C) →

B: Boiler , AH: Air Heater , GC: Gas Cooler
BF: Bug Filter , ECO: Economizer
RGH: Gas Reheater , SCR: Selective Catalytic Reduction

Table 1 Flow & equipment of facilities

3. Result & Discussion

3.1 Reduction of dioxins in exhaust gas

We considered that maintaining stable combustion and optimizing the design of the nozzle layout (in the secondary combustion chamber) and the re-combustion chamber configuration were most important for achieving an intensive improvement in combustion. A good balance among these factors was considered to be effective for reduction of dioxin generation.

Figure 1 shows dioxin emissions recently detected at incinerator outlets of Facility A, B, and C. It is shown that the CO concentration of all three facilities was stable at below 30 ppm and that the dioxin concentration at incinerator outlets of the same was 0.21 - 3 ng-TEQ/m3N. As the correlation between CO and dioxin concentrations is small below the CO concentration of 30 ppm, it can be understood that this correlation is unsuitable as an index for combustion improvement.

Figure 2 shows changes in dioxin concentrations in the exhaust gas discharged (per ton of municipal waste) from Facility A, B, and C. It is indicated that the dioxin concentration of Facility B is highest among the three facilities. The waste incinerated in Facilities A and C was segregated household waste. In contrast, that incinerated in Facility B was the same mixed with crushed flammable waste, the latter transported from an adjacent bulky waste treatment plant. Resynthesis in the boiler is assumed to derive from the difference in boiler configurations. Further investigation is in progress in regard to this.

The dioxin concentration at the BF outlet of each facility was: 0.036 ng-TEQ/m^3N for Facility A, : 0.042 ng-TEQ/m^3N for Facility B, and : 0.0015 ng-TEQ/m^3N for Facility C. These values were sufficiently below 0.1 ng-TEQ/m^3N. This suggests the possibility of control over dioxin generation in exhaust gas from incinerators, that matches the aforementioned 1997 Guideline, consequent to combustion improvement and lowering the temperature of the gas passing through the bag filter.

The SCR process (operated at SV = 1,550 - 1,650 L/h & temperature = 200°C) was used only at Facility C. The dioxin concentration at the SCR process outlet was found to be 0.0008 ng-TEQ/m^3N.

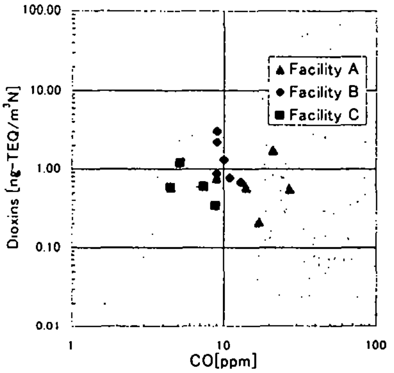

Figure 1 Comparison in dioxin emissions at incinerator outlets of Facility A, B, and C

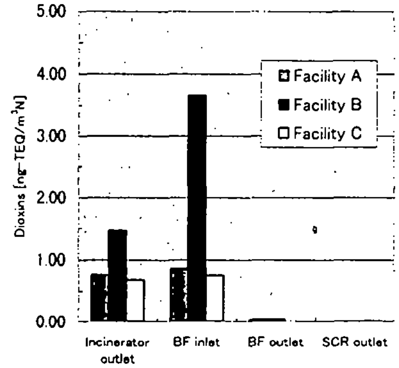

Figure 2 Changes in dioxin concentrations in the exhaust gas from combustion

Figure 3 shows the relationship between the exhaust gas temperature and dioxin concentration at dust collector outlets.

It is indicated that the dioxin concentrations tend to become smaller along lower exhaust gas temperatures. This is assumed to resulting from a conversion of gaseous dioxins into particle-form dioxins, the latter being easier for removal. The dioxin concentration at dust collector outlets was smaller because the dust collection efficiency was higher bag filters in comparison to that by electric precipitators.

The dioxin concentration was able to be easily reduced to below 0.1 ng-TEQ/m^{3}N. This was done by controlling dioxin generation by total combustion [3T = 1) high temperature combustion exceeding 850°C, 2) maintaining sufficient retention time (850°C for over 2 sec.), 3) intensified mixing and agitation] and lowering the exhaust gas temperature for preventing dioxin resynthesis and increasing the dioxin removal efficiency.

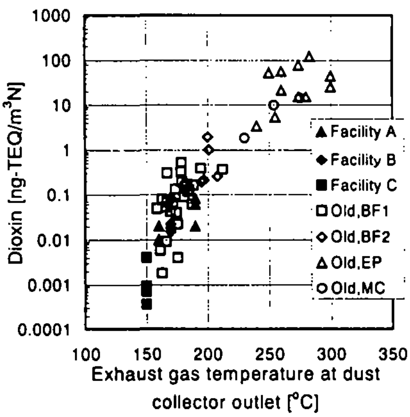

Figure 3 The relationship between the exhaust gas temperature and dioxin concentration at dust collector outlets

3.2 Total dioxin emission of below 5 μg/ t-waste

The amount of influent dioxins contained in municipal waste is reported as being 1 - 50 μg-TEQ/t-waste. However, further investigation is being suggested due to insufficient number of samplings and variations in the quality and composition of wastes. As for the present research, the concentration of dioxins detected from each ton of waste in Facility C was 1.3 - 16 μg-TEQ/t-waste.

In contrast, the total dioxin concentration was 0.0008 μg-TEQ/t-waste for exhaust gas, 0.97 μg-TEQ/t-waste for bottom ash, 9.12 μg-TEQ/t-waste for fly ash, constituting a total of 10.1 μg-TEQ/t-waste. This indicates that the total dioxin concentration was almost equal to, or slightly higher than that in the influent waste. Figure 4 shows the total dioxin emission of the three facilities, while Figure 5 shows percentages of the same.

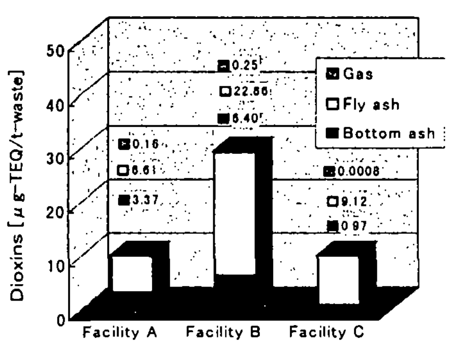

Figure 4 Total dioxin emission in Facility A. B. and C

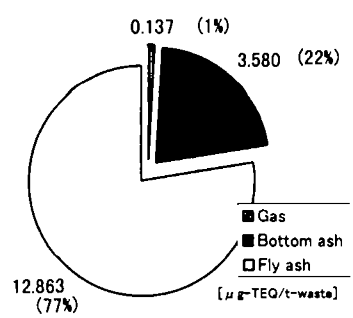

Figure 5 Percentage of total dioxin emission in Facilitv A. B. and C

The total dioxin emission from each of the said facilities was 10 - 30 μg-TEQ/t-waste, indicating that the target concentration of 5 μg-TEQ/t-waste was not attained. Figure 5 indicates that 99% of the dioxin emission derived from fly ash and bottom ash. In particular, it is noted that close to 80% constituted dioxin emission from fly ash. A reduction of dioxin emission toward the target 5 μg-TEQ/t-waste (stipulated in the 1997 Guideline) may be possible by controlling dioxin generation at the incinerator outlet and preventing the resynthesis of dioxins in the boiler and preheater. Furthermore, the most effective method of degrading dioxins may be the application of an ash melting system, by which bottom ash and fly ash will be melted and thermally dechlorinated. It has been demonstrated that about 98% of dioxins in fly ash can be degraded by thermal dechlorination. In another facility, Facility D, an ash melting system is being used along the incineration system. A dioxin degradation/ removal of about 99% is being achieved from the exhaust gas, molten ash and slag at this facility.

Figure 6 shows the ash melting flow at Facility D. Figure 7 shows the balance of dioxins at an incineration system equipped with an ash melting system.

The schematic diagram was made using the mean data for Facility A, B, and C merged with data from a simulation in which an incineration system equipped with an ash melting system was assumed. Use of the melting system made it possible to reduce the dioxin concentration in the bottom ash and fly ash, a total of 16.5 μg-TEQ/t-waste and which constituted the majority of the total dioxin emission, to 0.08 μg-TEQ/t-waste. It was assumed from this that it was possible to reduce the total dioxin emission at an incineration facility to 0.22 μg-TEQ/t-waste.

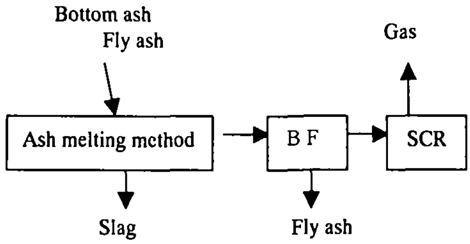

Figure 6 Dioxin degradation/removal ash melting and subsequent processes

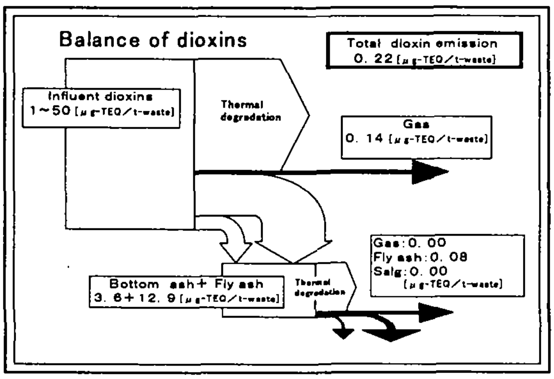

Figure 7 Balance of dioxins at an incineration system equipped with an ash melting system

4. Conclusion

Considering that the dioxin content in municipal waste is 1 - 5 μg-TEQ/t-waste, it may be necessary to reduce the total dioxin emission at an MSW incineration facility to below 5 μg-TEQ/t-waste. It was found effective to improve combustion and to add an ash melting system to an MSW incineration facility for attaining this figure, as well as for maintaining a stable total emission versus the various qualitative and quantitative factors of influent dioxins. Municipal waste incineration which makes effective use of energy and reduction of total dioxin emission may be considered an advantageous waste treatment method, when taking into account the domestic factors encompassing municipal waste treatment in Japan.

Reference

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