Technique for Reduction of Dioxin Emission in Waste Incinerators

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1. Foreword

A new technique for reducing dioxin emission in waste incinerators was developed in conformity with the Guideline for controlling PCDDs and PCDFs in municipal waste treatment * set by the Ministry of Health and Welfare, Japan in December 1990. This technique, initially developed for reducing dioxin emission in existing waste incinerators, features maintaining stable combustion at high temperature and providing a favorable secondary air mixture for creating an intense turbulent flow in the combustion chamber. The following discusses a case where the present technique was used in a new waste incinerator, built in full conformity to the above guideline.

2. Test Conditions

2.1 Outline of waste incinerator

The outline of the waste incinerator in which the present technique was used is shown in Table 1.

Table 1 Outline of waste incinerator

Item	Specifications
Incineration capacity	50 tons/d (25 tons/d x 2 furnaces)
Refuse calorific Value	800 ~ 2500 kcal/kg
Furnace type	Ebara Infilco stoker type
Recombustion chamber detention time	1.4 ~ 2.5 seconds
Gas cooling method	Water spray quenching
Flue gas treatment	Dry lime injection & Bag filter

2.2 Operating conditions of furnace

The furnace operating conditions during the tests are shown in Table 2.

* This Guideline is based the stand point that PCDDs/PCDFs discharge should be prevented as low as technically and practically possible. Under these condition, PCDDs/PCDFs are expected to amount to less than nearly 0.5 ng-TEQ/$m^3{}_N$ in a new continuous furnace. Other types of furnaces are expected to result much lower concentrations than at present.

The furnace operating conditions during the tests are shown in Table 2.

Table 2 Furnace operating conditions

Item	Conditions
Load percentage	100 ~ 110%
Refuse calorific value	1690 ~ 2180 kcal/kg
Excessive air rate	1.8 ~ 2.0
Temperature at combustion chamber outlet	750 ~ 1050 °C
Temperature at bag filter inlet	150 ~ 180 °C

3. Test Results & Considerations

3.1 Behavior of CO

3.1.1 Effect by temperature at combustion chamber outlet

The relationship between the temperature at the combustion chamber outlet and CO (12% O_2 converted) is shown in Figure 1. The relationship between the two in case of secondary air injection is indicated as exponential functions. There was rapid decrease in CO level along the increase in temperature. However, there was no correlation between the same in case of no secondary air injection and CO level rose even when the temperature stayed the same.

3.1.2 Effects by O_2

The relationship between the O_2 in the flue gas and CO is shown in Figure 2. When there was an injection of secondary air, as outlined in figure, there was good correlation between O_2 and CO, i.e. provided the O_2 was above 6%. However, when there was no injection of secondary air, there was no correlation between O_2 and CO, with the CO level increasing when the O_2 level was stayed the same. Therefore, it was considered that the role played by the secondary air was not only supplying oxygen, but providing a favorable air mixture for creating an intense turbulent flow in the combustion chamber. This was assumed to be the factor which contributed to reducing the CO level.

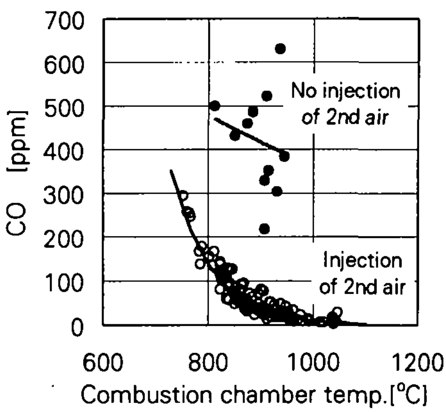

Figure 1 Relationship between combustion

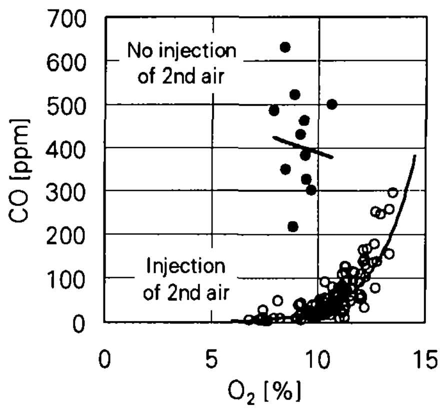

Figure 2 Relationship between O_2 and CO

chamber outlet temp. and CO

3.1.3 Effects by NOx

The relationship between the temperature at the combustion chamber outlet and NOx concentration (12% O_2 converted) is shown in Figure 3. There was tendency for the NOx level to gently increase with in the temperature range of 750 to 1050 °C. A NOx reduction of approximately 20% was confirmed when the spraying nozzles, installed for disposing leachate from refuse were used, as this causes a drop in the flame temperature, the filtrate atomizing nozzles were used, as this causes a drop in the flame temperature. As there is no rapid surge in NOx caused by a rise in temperature, when the combustion chamber outlet temperature is below 1050 °C, it is assumed that combustion at a high temperature for reducing the CO is desirable.

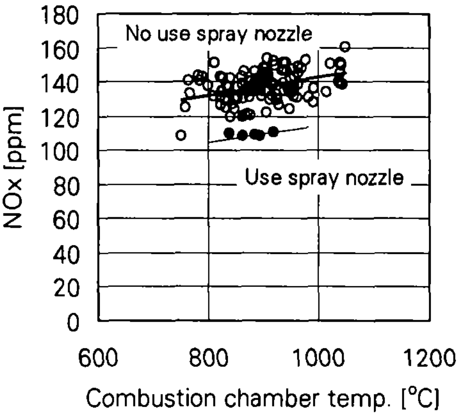

Figure 3 Relationship between combustion chamber outlet temp. and NOx

3.2 Behavior of dioxins
3.2.1 Correlation with CO

The relationship between the Dioxins (DXNs)(TEQ) at the gas cooling chamber (GC) outlet and bag filter (BF) outlet, and CO is shown in Figure 4. The DXN level at the GC outlet was 0.4 ~ 5.5 [ng/$m^3{}_N$ - TEQ], showing a tendency of decrease along the decrease in CO level. In contrast, the average DXN level at the BF outlet was 0.11 [ng/$m^3{}_N$ - TEQ], fully complying the expected value stated in the *Guideline* for continuous furnace.
The difference between DXNs at the GC outlet and those at the BF outlet is due to the removal of DXNs by the BF, meaning that the BF is greatly effective for DXN removal.

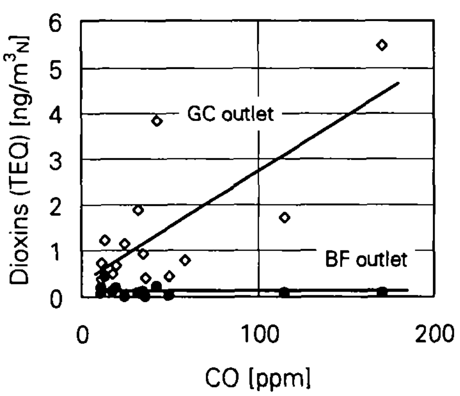

Figure 4 Relationship between dioxins

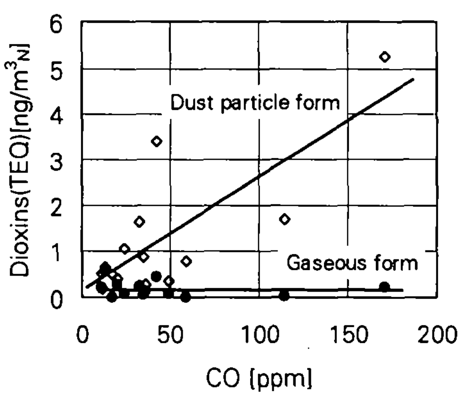

Figure 5 Dioxins at GC outlet according to

at GC & BF outlet, and CO type

Figure 5 shows analysis results of DXN at the GC outlet in both dust particle and gaseous form, the former being that collected by a thimble filter and the latter being that which passed this filter. As acknowledged from the figure, CO is affecting changes only in the dust particle form DXNs. The concentration of the gaseous form DXNs is at a constant and low, average of 0.18 [ng/m^3_N - TEQ], regardless of the CO level. Correlation found between GC outlet DXNs and CO mostly involved dust particle form DXNs, a fact which may be attributed to correlation with CO.

3.2.2 DXN removal by bag filter

As indicted in 3.2.1, the majority of DXNs at GC outlet are dust particle form DXNs collected by the thimble filter. As the removal of the dust particle in the bag filter generally exceeds 99.9%, it can be assumed that almost all dust particle form DXNs are completely removed. Figure 6 shows the correlation between gaseous DXNs at the GC outlet, i.e. those which passed the thimble filter, and total DXNs at the BF outlet. The DXN level at the BF outlet is lower than that of gaseous form DXNs at the GC outlet, the removal being approximately 60%. It is assumed that a part of the gaseous form DXNs are removed by becoming adsorbed by dust layers.

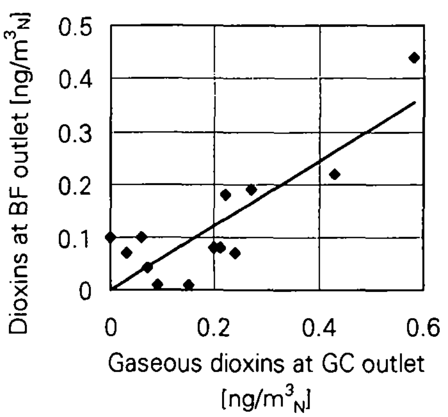

Figure 6 Relationship between Gaseous DXNs at GC outlet and DXNs at BF outlet

3.2.3 Unsteady state DXN behavior

Figure 7 shows the daily DXN emission percentage, including that during unsteady states. Despite the short startup time, approximately 0.7 hours, this constitutes 31% of the daily discharge amount as the DXN level is high at 5.3 [ng/m^3_N - TEQ]. In contrast, the steady state is 16.2 hours, with an average DXN level of 0.11 [ng/m^3_N - TEQ], constituting 57% of the daily discharge amount. The average daily discharge concentration, including that during unsteady states, is 0.17 [ng/m^3_N - TEQ]. Although the DXN level at startup is high, this covers a short time. Therefore, the average discharge concentration fully complies with the expected figure 0.5 [ng/m^3_N - TEQ] stated in the *Guideline* for a continuous furnace.

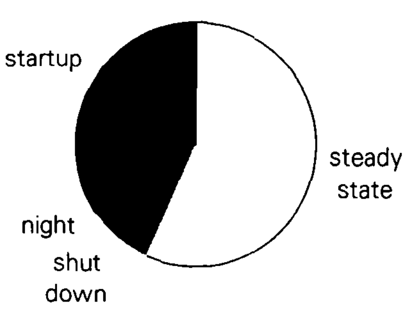

Figure 7 Daily Dioxin discharge ratio, including that during unsteady states

4. Conclusion

4.1 CO behavior

(1) Maintaining the 3Ts is essential for reducing CO. Effects by the temperature at the combustion chamber outlet are greatest in importance, followed by the provision of a favorable secondary air mixture for creating an intense turbulent flow in the combustion chamber, and the detention time.
(2) In case there is a provision of secondary air, the CO level is stable at below 50 ppm when the temperature at the combustion chamber outlet is above 900 □C. When the O_2 level of the flue gas is above 6% and the temperature at the combustion chamber outlet is under approximately 1050 °C, the O_2 level is low; therefore, the CO level is lower when the temperature at the combustion chamber outlet is higher.
(3) Changes in the NOx concentration, in high combustion regions of up to approximately 1050 °C, are within 120 ~ 160 ppm, with no significant increase. Therefore, there is little effect on NOx by maintaining a high combustion chamber outlet temperature for reducing CO. Water spray quenching directed on the furnace frame, substituting for disposal of leachate by spray nozzle, achieves a NOx reduction of approximately 20%.

4.2 Dioxin behavior

(1) *There is favorable correlation between CO and DXNs at the GC outlet, thus there is a* possibility that CO level may used as an index for the generation of DXNs. However, there was no correlation found between CO and gaseous form DXNs, as far as the configuration of the present furnace and its operational conditions are concerned.
(2) The removal rate of DXNs by the bag filter was great as the majority of DXNs were taking a dust form. A 60% removal of gaseous form DXNs was achieved in the BF.
(3) The average DXN level at the BF outlet was 0.11 [ng/$m^3{}_N$ - TEQ], fully complying with the expected figure 0.5 [ng/$m^3{}_N$ - TEQ] stated in the *Guideline* for a continuous furnace.
(4) DXNs during unsteady state were greatest, an average of 5.3 [ng/$m^3{}_N$ - TEQ] during startup, which constituted 31% of the daily discharge amount. However, the average daily discharge concentration, including that during unsteady states, was 0.17 [ng/$m^3{}_N$ - TEQ]; *therefore, the average discharge concentration fully complied with the expected figure 0.5* [ng/$m^3{}_N$ - TEQ] stated in the *Guideline* for a continuous furnace.

5. Reference

M. Hiraoka: Formation and control of Dioxins in Municipal Waste Treatment, WASTE MANAGEMENT RESEARCH Vol.1 No.1, 1990.

Ministry of Health and Welfare: Guidelines for controlling PCDDs/PCDFs in Municipal Solid Waste Treatment, December 1990.

Joichi Iori, Yasuhiro Fukaya, Isao Ohba, Shinya, Takenaka: Bag Filter System for MSW Incinerator, The Kyoto Conference on Dioxins Problem of MSW Incineration, 1991

Hajime Jinbo ,Youji Satou: Bag Filter, reuse of Electrostatic Precipitator, Proceedings of 4th Symposium of The Japan Society of Waste Management Experts, 1993

Masaaki Unno, Youji Satou, Osamu Futamura, Sayaka Ozawa: The Reduction of Dioxins in Improved Existing Furnace, Proceedings of 15th Symposium Japan Waste Management Association, 1994