The Effects of Operation Conditions on PCDD/Fs Emission in Municipal Solid Waste Incinerators: Stack Gas Measurement and Evaluation of Operating Conditions

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INTRODUCTION

Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzo furans(PCDFs) are considered as the most serious pollutants generated in municipal solid waste incinerators (MSWI). In incineration process, PCDD/Fs are recognized to be formed by De-novo synthesis in the furnace during the combustion process and off-gas treatment systems[1]. While the detail of the formation mechanism of PCDD/Fs formation is not still fully understood, most of the recent researches to evaluate the incinerator's performance were carried out by experimental methods and statistical analysis [1-6].

In Korea, 10 large scale MSWI are in operation, of which 9 systems are stoker type and another is fluidized bed type. They are equipped with various flue gas treatment systems. In the present study, measurement results of the stack gas in 10 municipal solid waste incinerators are presented. The emission rate of PCDD/Fs were measured, and concentration of oxygen, CO, HCl, particulate matter were monitored continuously. The relationships of operation parameters with PCDD/Fs emission rate and the ratio of PCDFs to PCDDs are discussed.

INCINERATION SYSTEMS IN KOREA & MEASUREMENT OF EMISSIONS

The MSWIs in operation is shown in Table 1. Six incineration systems consist of electro-static precipitator (ESP) and wet scrubber, and three of them have selective catalytic reactor (SCR) for NOx removal. Three systems have spray drying absorber (SDA) and bag filter, of which one includes SCR. The last is a FBC type that have water quencher, dry injection absorber (DI) and bag filter. In the present study, incinerators are classified into 3 classes for systematic viewpoint

to derive influential parameters on PCDD/Fs emission rate;

Class 1: including ESP and Wet Scrubber without SCR: Incinerator No. 1-3
Class 2: including ESP and Wet Scrubber with SCR : Incinerator No. 4-6
Class 3: including Bag Filter and SDA/DI (SCR) : Incinerator No. 7-10

Table 1. Operating municipal solid waste incinerators in Korea

Incinerator	Type (ton/day)	Off-Gas Treatment Systems	Commission
1	Stoker (200)	Boiler – ESP – Wet Scrubber	1992.12
2	Stoker (200)	Boiler – ESP – Wet Scrubber	1995.6
3	Stoker (200)	Boiler – ESP – Wet Scrubber	1995.9
4	Roller Grate (400)	Boiler – ESP – Wet Scrubber – SCR	1996.9
5	Stoker (300)	Boiler – ESP – SCR – Wet Scrubber	1995.12
6	Stoker (200)	Boiler – ESP – Wet Scrubber – SCR	1996.10
7	Stoker (200)	Boiler – SDA – Bag Filter	1995.3
8	Stoker (200)	Boiler – SDA – Bag Filter – SCR	1996.3
9	Stoker (200)	Boiler – SDA – Bag Filter	1994.1
10	FBC (50)	Water Quencher–Dry Injection–Bag Filter	1993.12

PCDD/Fs of the stack gas is analyzed according to Korean standard measurement method. The PCDD/Fs concentration of the collected samples is measured by a high resolution GC/MS. Along with the stack gas sampling, operation conditions and other emission gases (O_2, CO, HCl, Dust, etc) are checked concurrently and continuously.

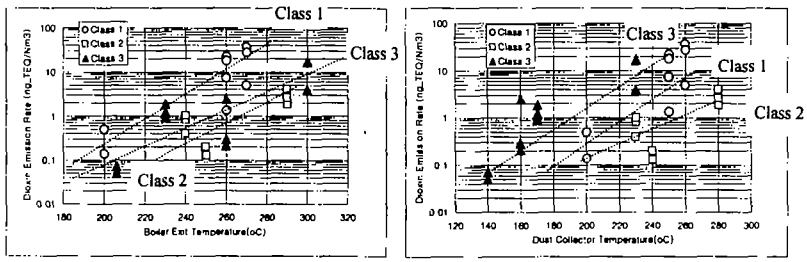
RESULTS AND DISCUSSION

Typical measurement result of PCDD/Fs emission rate are shown in Fig. 1, which shows inconsistency on the homologue patterns as well as the total emission rates from case to case. Process temperature, dust emission appeared to be influential parameters on PCDD/Fs emission rate. Fig. 2 shows the relation of the process temperatures with PCDD/Fs emission. Waste heat boilers have the temperature range of 250 – 450 °C and several seconds of flue gas residence time which is enough for the formation of appreciable PCDD/Fs[1]. Fig. 2 shows that high process temperature of the boiler and the dust collectors results in high PCDD/Fs emission. The incinerators of Class 1 and Class 2 have ESP after the boilers, so that high boiler temperature is connected with high ESP temperature. Incinerators of Class 2 show approximately one order lower level of PCDD/Fs emission than Class 1 that have no SCR[6]. Fig. 3 shows the relationship of other parameters with PCDD/Fs emission rate. Higher dust concentration at the stack is connected to higher PCDD/Fs emission rate. However, oxygen and carbon mono-oxide show no significant relationship with PCDD/Fs emission. The ratio of PCDFs to PCDDs shows rather strong relationship with PCDD/Fs emission as shown in Fig. 3(d), wherefrom it is expected that

PCDFs are more sensitive species than PCDDs to the formation and the removal mechanisms.

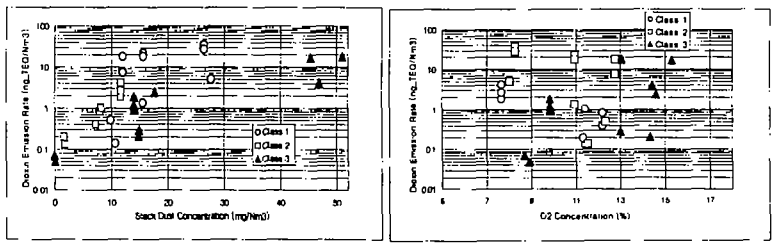
(a) No. 2 (b) No. 5

Fig. 1 Typical homologue distribution of PCDD/Fs.

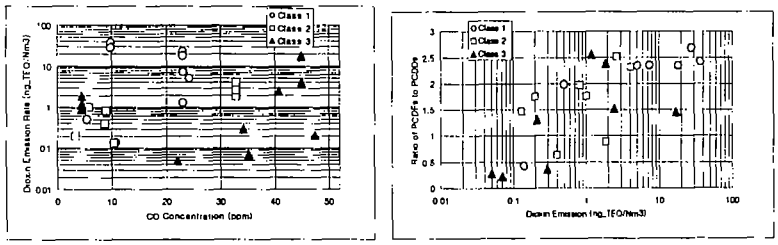


(a) Boiler exit gas temperature (b) Dust collector temperature.

Fig. 2 Effects of element temperatures on PCDD/Fs emission rate.



(a) Dust concentration (b) O_2



(c) CO (d) The ratio of PCDFs to PCDDs

Fig. 3 Relationship between PCDD/Fs with operating parameters

CONCLUSION

PCDD/Fs emission rates of 10 incinerator plants have been measured and the results were discussed along with the operation parameters and the plant system configuration. Interpretation of the results were not straightforward, because many of the parameters are not fully understood and possibly interrelated. The measurements results showed the emission level of 0.07-27.9 ng TEQ/Nm^3, wide variation from one plant to another, and less than satisfactory repeatability.

PCDD/PCDFs level at the stack is the result of the formation and destruction along the flue gas flow path from the furnace. Measurement results of one plant must be discussed with the process system configuration of it own, and cross comparison with the results from other plants should be treated only with extreme care. As a way of comparative discussion of PCDD/PCDFs measurement results, the incineration plants were divided into 3 groups, based on the process system configuration. Given the process of the incinerator plant, temperature of the exhaust gas from the furnace to the stack was considered one of the major parameter, followed by the dust contents of the flue gas. Oxygen and carbon monoxide concentration of exit gas were not considered as controlling parameter. Plants equipped with catalytic NOx reactor seemed to show lower level of PCDD/Fs. The ratio of PCDFs to PCDDs showed close relationship with total PCDD/F level, which suggested that PCDFs were more sensitive to the formation and removal mechanism in the flue gas treatment system.

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