CONTROL OF PCDDs AND PCDFs BY THE HIGH TEMPERATURE/HIGH TURBULENCE INCINERATION

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ABSTRACT

Control methods of PCDD/PCDF were discussed by the high temperature and high turbulence incineration. Field plant testing has been done using a 300 t/d continuous incinerator of water wall type with rotary kiln designed to incinerate municipal solid waste. PCDD/PCDF concentrations were relatively lower than those of other stoker type furnaces in Japan. The reason of this low PCDD/PCDF seems to be due to the high turbulence condition in the incineration chamber caused by its furnace structure. There is a positive correlation between PCDD/PCDF and CO concentrations which is a typical unburnt gas component at the outlet of waste heat boiler. For the purpose of reducing dioxins and their precursors contained in the exhaust gas and fly ashes, it may be an important factor to lower the inlet temperature of dust collector.

KEYWORDS

PCDDs, PCDFs, precusors, municipal waste, incineration

INTRODUCTION

Dioxins, polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) discharged from waste incineration plants are posing a problem in recent years because of its high toxicity. The authors investigated the relationship between operating conditions of a waste incineration plant and PCDDs and PCDFs (PCDD/PCDF). Chlorophenols (CPs) and chlorobenzenes (CBs) known as their precursors were also measured. Control methods of PCDD/PCDF were discussed by the high temperature and high turbulence incineration.

FIELD TESTING METHOD

Test plant and its Operating Conditions

The test plant was a 300 t/d continuous incinerator of water wall type with rotary kiln designed to incinerate municipal solid waste. PCDD/PCDF and their precursors were measured at four sampling points along the exhaust gas flow : incinerator outlet, electrostatic precipitator (ESP) inlet, ESP outlet and wet scrubber outlet. Fly ashes were sampled at the ESP outlet. Measurements were done under four cases of operating conditions. The four operational conditions are shown in Table 1. The plant was operated at a normal loading rate in case ①, and at a high loading in cases ②, ③, and ④. In case ②, the plant was operated under the condition that the temperature at ESP inlet was high. In cases ①, ③, and ④, the temperature at ESP inlet was relatively low. In cases ③ and ④, the plant was operated at almost equal conditions, however the incinerator outlet temperature in case ④ was higher than case ③.

Analytical Methods

Sampling was carried out by a 5-impinger method in isokinetic conditions and dust collecting parts were usually placed at outside the duct. Samples were extracted with toluene (dust was extracted after digesting with hydrochloric acid). The internal standards of ^{13}C-2,3,7,8-T_4CDD, ^{13}C-2,3,7,8-T_4CDF, ^{13}C-O_8CDD, ^{13}C-O_8CDF were added and the mixtures were concentrated and cleaned up. Analysis was carried out by mass fragmentgraphy using a DB-5 and SP-2331 as separation columns. Quantification was carried out by the peak area method using M, M+2 or M+4 as the monitoring ion. For the 2,3,7,8- substitution standards of each congeners of PCDD/PCDF were used. On the other hand, chlorobenzenes and chlorophenols were analyzed by means of GC/MS.

Table 1 Operating Conditions of the Test Plant

Run No.	①	②	③	④
Loading rate [$\times 10^3$kg/h]	11.8	15.1	14.8	14.8
Temp. at incineration chamber [℃]	927	863	918	1018
Temp. at gas mixing zone [℃]	876	909	895	921
Temp. at ESP inlet [℃]	257	305	271	264
Temp. at ESP outlet [℃]	250	292	264	255

RESULTS AND DISCUSSIONS

PCDD/PCDF and their Precursors in the Test Plant

The changes in the concentrations of 2,3,7,8-TCDD equivalents by I-TEF (International Toxic Equivalent Factors) in each test run are shown in Fig.1. CBs and CPs are shown in Fig.2. PCDD/PCDF concentrations were relatively lower than those of other stoker type furnaces in Japan. The reason of this low PCDD/PCDF seems to be due to the high turbulence condition in the incineration chamber caused by its furnace structure. PCDD/PCDF increase in the waste heat boiler in all cases, however, precursors decrease in some of the cases. Both PCDD/PCDF and their precursors show almost the same increasing trend in ESP. The higher the ESP inlet temperature, the larger their concentrations tend to increase. In wet scrubber, both dioxins and their precursors tend to decrease.

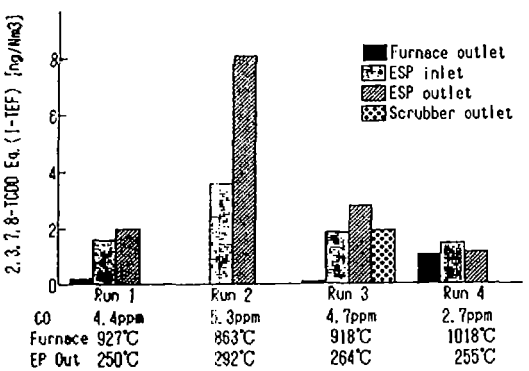

Fig. 1 PCDD/PCDF Concentrations as 2,3,7,8-TCDD Eq.

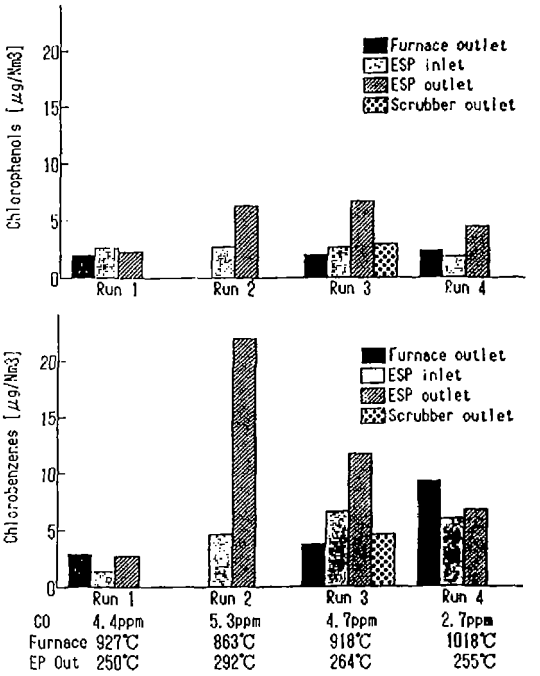

Fig. 2 Concentrations of Chlorophenols (CPs) and Chlorobenzenes (CBs)

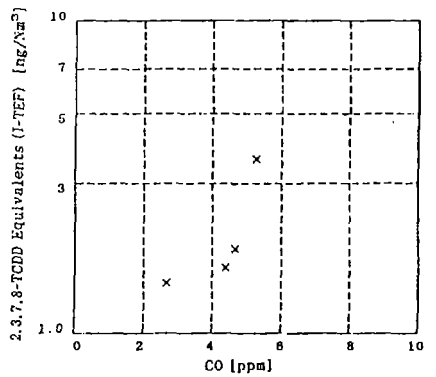

Fig. 3 CO versus 2,3,7,8-TCDD Eq. of Exhaust Gas

Correlating between Incineration Parameters and PCDD/PCDF

Carbon monoxide (CO) is said to be one of the parameters of the complete incineration for solid waste. As to the correlation between CO and PCDD/PCDF at the outlet of waste heat boiler (ESP inlet), a positive correlation exists as shown in Fig.3. The CO value is the measured value obtained by means of gas chromatography which said to be more accurate without being influenced by other components (CO_2 and H_2O) in the exhaust gas.

Correlation between PCDD/PCDF and their Precursors

From the data obtained through the measurements, PCDD/PCDF cannot be seen to correlate with CBs and CFs. All exhaust gas at every sampling points were shown that the PCDDs had the isomeric pattern of the higher chlorination degree. On the other hand, with the PCDFs, the lower chlorination degree were dominated for the exhaust gas of ESP inlet, ESP outlet and gas scrubber outlet. In the case of furnace outlet exhaust gas, isomers pattern of PCDFs were almost the same.

PCDD/PCDF and their Precursors in Fly Ash

PCDD/PCDF and their precursors in fly ashes have the strong positive correlation with ESP temperature as shown in Fig.4. The isomers pattern were shown to be distributed on the high chlorination degree side.

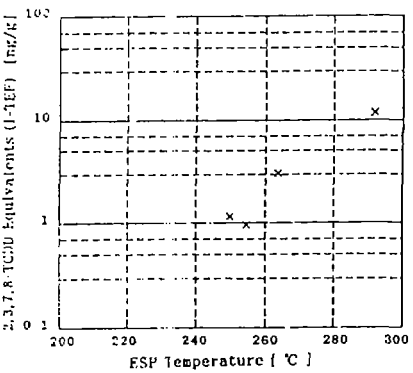

Fig. 4 ESP temperature versus 2,3,7,8-TCDD Eq. of Fly Ash

CONCLUSIONS

1) There is a positive correlation between PCDD/PCDF and CO concentration which is a typical unburnt gas component at the outlet of waste heat boiler, the inlet of dust collector. Also, chlorophenols have the same correlation with CO. It may be said that the complete combustion of unburnt gas in the incineration plant is one of the critical factors to control the PCDD/PCDF formation.

2) There is a positive correlation between the dust collector inlet temperature and the dioxins and their precursors from the data under almost the same incinerating conditions less than CO concentration of 7 ppm. Lowering the dust collector inlet temperature is also one of the important factors.

3) For the purpose of reducing dioxins and their precursors contained in fly ashes, it may be an extremely important condition to lower the inlet temperature of dust collector.

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