POPs BEHAVIOR IN EXPERIMENTAL FABRIC FILTER EQUIPPED WITH ALUMINUM ALLOY SMELTING FURNACES

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Introduction

Municipal waste incinerators have been a major source of emissions of unintentionally produced persistent organic pollutants (POPs). Much attention is now directed to other sources of the unintended by-products, referred to by the provisions of the Stockholm convention, such as industrial emissions including secondary metals smelters and sinter plants.

In the recent past, much effort has been made to reduce POPs emissions from aluminum alloy smelting plants which recycle aluminum scrap. According to the latest inventory in Japan, it is the third largest source of dioxin emissions except from municipal waste incinerators[1]. Since aluminum alloy smelting plants are mostly small-scale in Japan, it is difficult that POPs emissions are drastically reduced by installing advanced gas cleaning processes such as post-combustor and quenching chamber. Utilizing fabric filters of smelting furnaces is reasonable measures by setting their operating conditions appropriate. However, it was reported that removal efficiency of dioxins by fabric filters of smelting furnaces was often lower than expected when the temperature was set to the value which was generally recognized to be sufficiently low in case of waste incinerators[2]. It is difficult to say that POPs removal by fabric filters is the best available technology (BAT) in aluminum alloy smelting plants.

Unintentionally produced POPs emission was investigated in recent research by using the experimental fabric filter added to the aluminum alloy smelting plant[3]. The aim of these experiments was to find out operating conditions of fabric filters which were suitable for reduction of POPs emissions from smelting plants. In this paper, POPs behavior was studied in the experimental fabric filter by measuring the concentrations of polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs), polychlorinated biphenyls (PCBs), and hexachlorobenzene (HCB) in flue gas and fly ash.

Materials and methods

The experimental fabric filter was equipped with the aluminum alloy smelting plant in operation[3]. The flue gas line from the furnaces branched off and led to the experimental fabric filter (Figure 1). The investigation on the temperature of flue gas at the inlet of the filter was conducted on 1st day. Different values of filtration rate and pressure drop of the filter were set on 2nd day. Sodium hydroxide solution and activated carbon were injected into the flue gas line on 3rd and 4th day.

Sampling ports were located at the inlet and the outlet of the experimental fabric filter. Sampling of flue gas for POPs analysis was carried for a certain period from these ports three or four times in a day. Fly ash was collected from the bottom of the filter at the end of the day. The amount of fly ash in flue gas entered into the filter could not be estimated in this experimental apparatus. Experimental conditions and analytical procedures for dioxin-like compounds, PCBs, and HCB were described elsewhere[3]. Typical temperature of flue gas was 110 °C at the inlet of

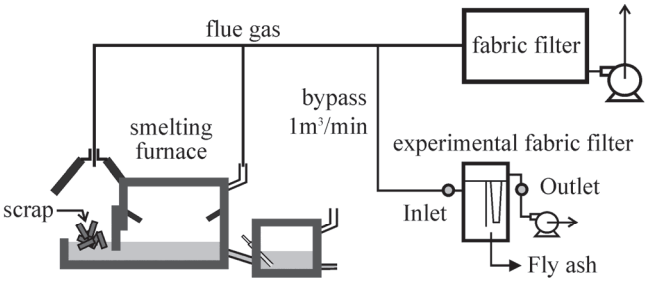

Figure 1. Schematic diagram of flue gas lines and fabric filters.

the experimental fabric filter. This temperature is generally recognized to be sufficiently low for reduction of POPs emissions by using fabric filters in case of waste incinerators.

Results and discussion

Average concentrations of POPs in flue gas samples in a day and those in fly ash collected at the end of the day are listed in Table 1. POPs concentrations, particularly PCBs and HCB, in fly ash were very high on 4th day, which was caused by activated carbon injection. Activated carbon injected into flue gas adsorbed these pollutants and was collected with fly ash from the bottom of the experimental fabric filter. This assumption coincides with the results of flue gas sampling[3]. The influence of the adsorption was also observed in homologue profiles and congener distribution patterns of PCDD/Fs, which were apparently different from those on the other days. Therefore, the results on 4th day were excluded from the discussion below. Concentrations of dioxin-like compounds and HCB in fly ash increased as the days went by and show no correlation with those in flue gas samples. These by-products probably accumulated in fly ash on the surface of the filter. As for PCBs, large changes of their concentrations in flue gas at the inlet mainly affected those in fly ash.

Table 1. POPs concentrations in flue gas samples and fly ash.

	Dioxins			PCBs			HCB		
	Inlet [ng/m^3]	Outlet [ng/m^3]	Fly ash [ng/g-dry]	Inlet [ng/m^3]	Outlet [ng/m^3]	Fly ash [ng/g-dry]	Inlet [ng/m^3]	Outlet [ng/m^3]	Fly ash [ng/g-dry]
1st day	130	13	23	6200	2300	170	64	28	0.53
2nd day	94	51	24	860	950	77	100	96	1.0
3rd day	34	12	63	530	380	58	57	35	4.4
4th day	-	27	120	-	320	580	-	17	100

Figure 2 shows changes of relative homologue profiles of PCDD/Fs in flue gas at the inlet and outlet of the fabric filter and in fly ash collected. Proportions of PCDD homologues hardly changed in flue gas at the inlet, but the homologue profiles were shifted toward higher chlorinated species in flue gas at the outlet and in fly ash from 1st to 3rd day. This indicates that reactions such as formation, chlorination, or selective decomposition were occurred in fly ash on the surface of the filter at these experimental conditions. Higher chlorinated species tend to be formed via breakdown of carbon and PAHs[4]. Selective decomposition means that lower chlorinated species are selectively decomposed in fly ash. It seems that these pollutants entered into the fabric filter accumulated on the surface of the filter and some reactions proceeded in fly ash. A part of the pollutants volatilized into flue gas and the others were collected with fly ash from the bottom of the fabric filter. The profiles of PCDF homologues were shifted toward higher chlorinated species in all samples. POPs entered into the fabric filter might be distributed into flue gas and fly ash. The change of relative homologue profiles of

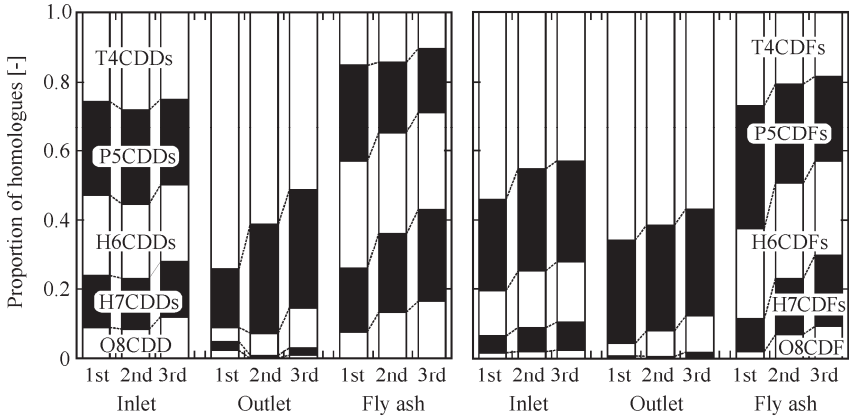

Figure 2. Changes of relative homologue profiles of PCDD/Fs in flue gas at the inlet and outlet of the fabric filter and in fly ash.

PCDFs in flue gas at the inlet could be associated with memory effects on the inner surfaces of flue gas lines from the furnaces[5].

Figure 3 shows changes of congener distribution patterns of P5CDD/Fs and H6CDD/Fs in flue gas at the inlet and outlet of the filter and in fly ash collected. Similar trends were observed in other homologues. Changes of congener proportions of P5CDDs and H6CDDs in flue gas at the outlet were closer to those in fly ash than in flue gas at the inlet. This agrees with the results of the PCDD homologue profiles. For PCDFs, congener proportions in flue gas at the outlet and in fly ash showed similar changes as the days went by. These changes were different from those in flue gas at the inlet in many congeners. Congener distribution patterns of PCDFs show evidence of some reactions in fly ash on the surface of the filter as well as those of PCDDs although the

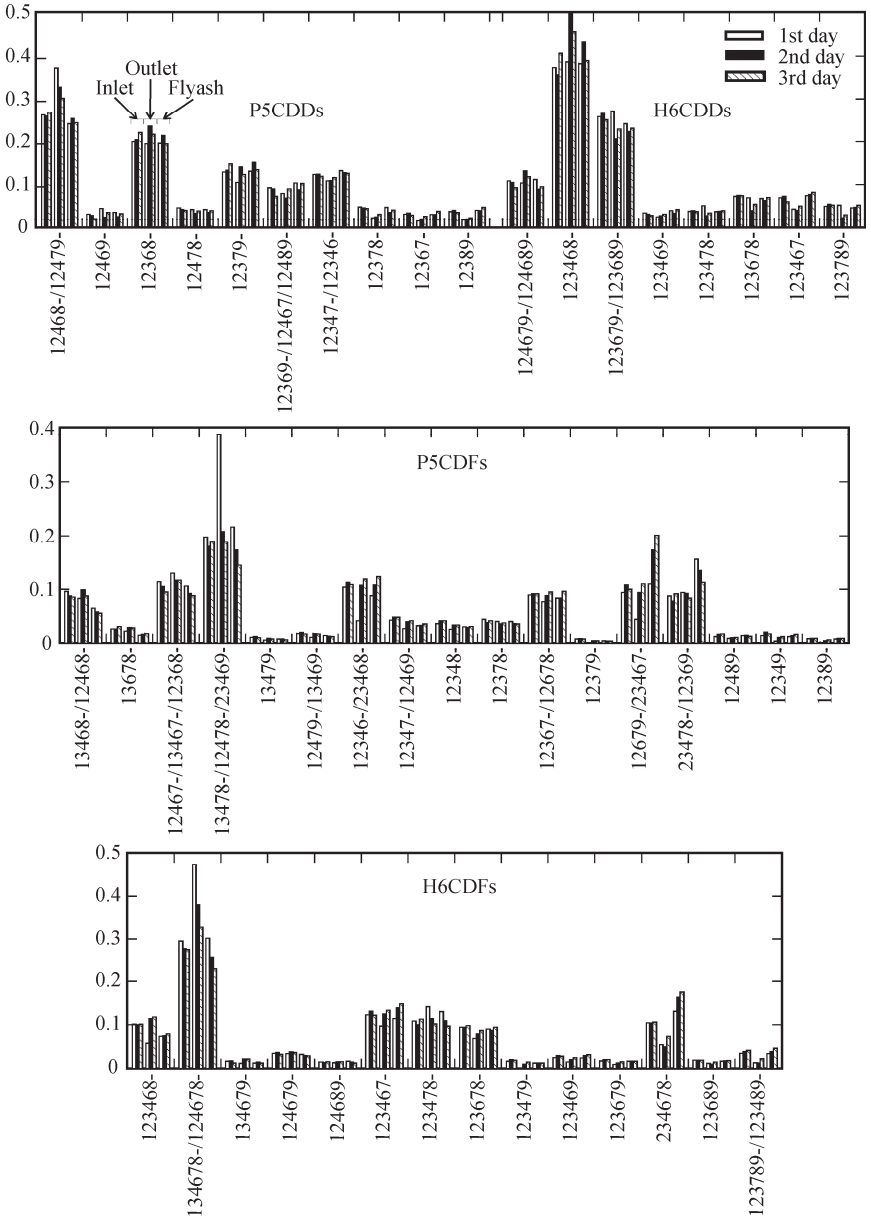

Figure 3. Congener distribution patterns of P5CDD/Fs and H6CDD/Fs in flue gas at the inlet and outlet of the fabric filter and in fly ash.

typical temperature in the fabric filter was sufficiently low. Additionally, proportions of some congeners of P5CDD/Fs and H6CDD/Fs largely changed in flue gas at the outlet and in fly ash though there were only small differences at the inlet of the filter from 1st to 3rd day. The differences of changes of congener proportions in flue gas at the inlet and the outlet means different reaction mechanisms of PCDD/Fs between in flue gas lines from the smelting furnaces and on the surface of the experimental fabric filter. Large changes of congener proportions in flue gas at the outlet and in fly ash are probably associated with formation reactions of PCDD/Fs[4].

Acknowledgements
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