Memory Effect in Intermittent Operation of MSW Incinerators

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1. Introduction

The authors have previously reported that high concentrations of dioxins (PCDDs, PCDFs) are emitted during the shut-down of existing small-scale mechanical batch incinerators operating 8 hours a day[1,2]; and, by the application of Japanese government guidelines for the design and operation of new mechanical batch facilities, total daily dioxin emissions can be greatly reduced to one-twentieth of conventional levels[2]. In these investigations, a phenomenon was observed in which, under steady-state operation, the concentration of PCDDs/PCDFs in the bag house outlet gas actually becomes higher than that in the inlet gas.

In continuation of a project on dioxin control technology funded by the Ministry of Health and Welfare and the Environment Agency, two investigations were carried out at the same facility (Facility B) in fy 1993 to determine the reason for this increase in dioxin content within the bag house.

We also performed laboratory experiments to reproduce this phenomenon and obtained the same results as were achieved from the investigations with the actual facility. From the results, we showed that the cause of this increase is a "memory effect" from shutdown and start-up.

2. Investigations on the Actual Facility

In the first investigation, countermeasures were taken against the increase of dioxin content in the bag house. However, the countermeasures proved ineffective; and the phenomenon reappeared as before.

In the second investigation, we extended the operating time of the unit and, as a result, found from data sampled 3 to 5 hours after start-up as steady-state operation data has a strong memory effect from shutdown/start-up. That is, within this time period, the increase in PCDDs/PCDFs through the bag house became progressively more conspicuous as the inlet concentration at the dust collector dropped in conjunction with such dioxin-suppression measures as combustion optimization and air preheater outlet gas temperature reduction — a concentration of 1.2 ng/m^{3}N (I-TEQ) at the inlet increased to a concentration of 6.2 ng/m^{3}N (I-TEQ) at the outlet (RUN 3). An examination of data sampled 11 to 13 hours after start-up revealed that the memory effect had weakened considerably — a concentration of 1.4 ng/m^{3}N (I-TEQ) at the dust collector inlet decreased to a concentration of 0.14 ng/m^{3}N (I-TEQ) at the outlet (RUN 4). Analysis results are shown in Table 1; changes in congener pattern, in Figure 1; and concentrations of dioxins (I-TEQ) by sample timing, in Figure 2.

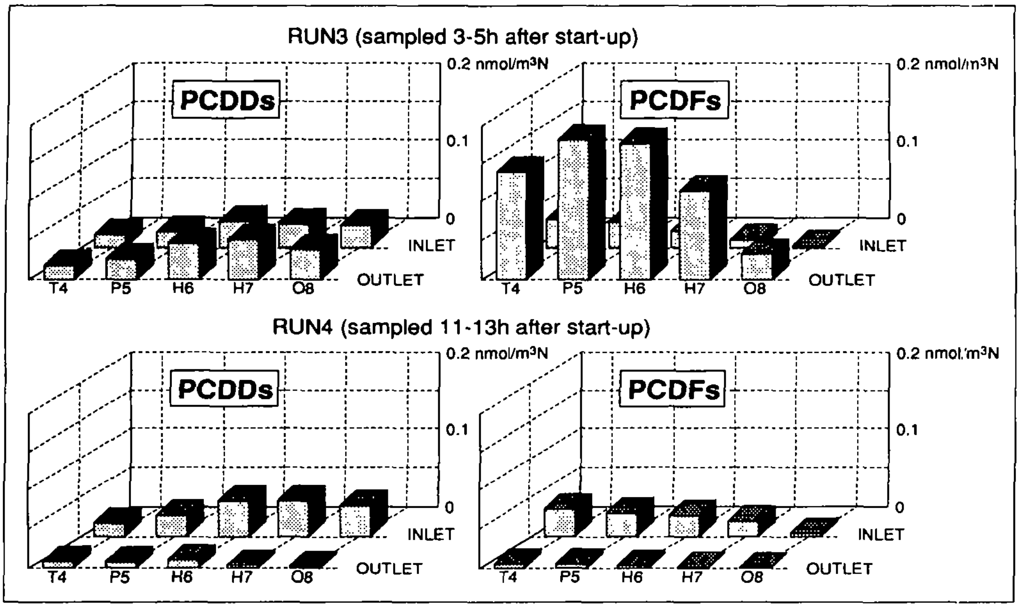

Fig. 1 Change of Congener Pattern through Bag house

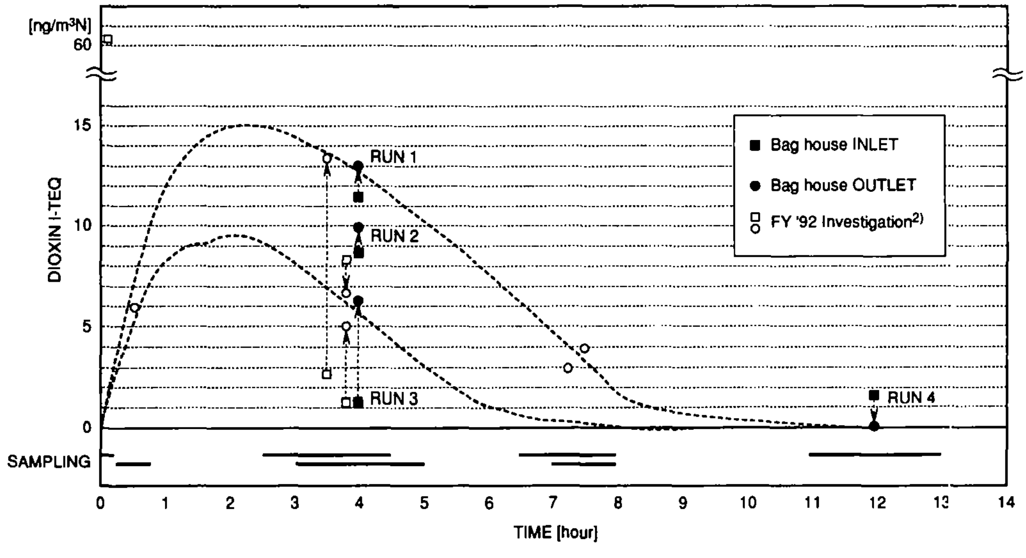

Fig. 2 Sampling Timing and Dioxin

3. *Laboratory Experiments to Reproduce the Phenomenon*

There have been a number of pioneering research efforts on the formation of dioxin by dust catalysis[3,4,5), etc.] and many significant results have been achieved. We gratefully referred to these results as we attempted to reproduce the phenomenon in a laboratory. Our experiments can be distinguished from previous efforts by the emphasis we placed on the following areas.

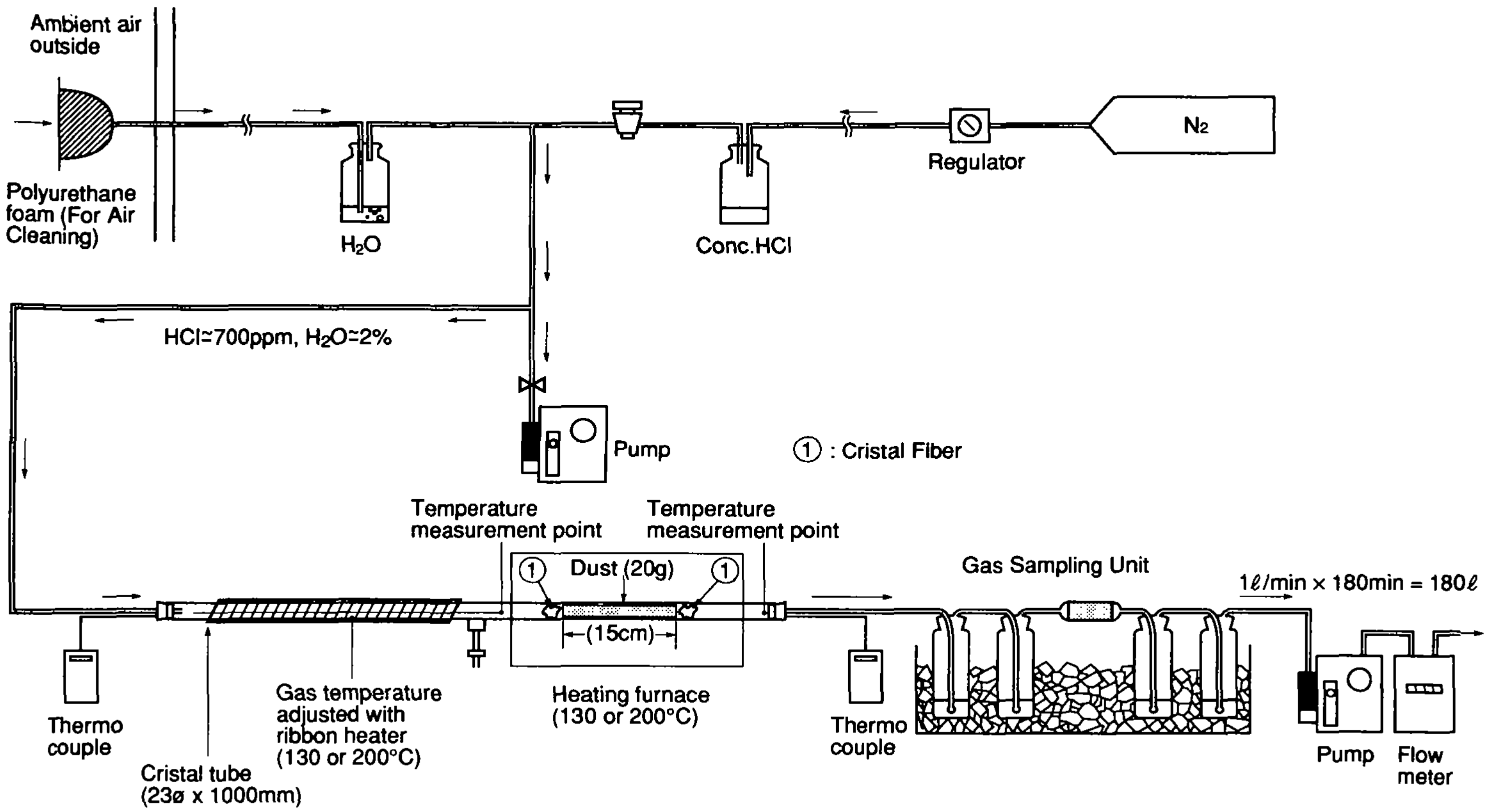

Fig. 3 Laboratory Apparatus for the Dioxin Formation using Filter-adhered-ash

Table 1. Investigation Data (Facility-B)

	Unit	RUN1 (sampled 3-5h after start-up, Lime 3.5g/m³N)			RUN2 (sampled 3-5h after start-up, Lime 3.5g/m³N)			RUN3 (3-5h after start-up Lime 3g, Carbon 150mg/m³N)			RUN4 (11-13h after start-up Lime 3g, Carbon 150mg/m³N)		
		BH-in	BH-out	BH-dust	BH-in	BH-out	BH-dust	BH-in	BH-out	BH-dust	BH-in	BH-out	BH-dust
Gas Temp.	°C	160			190			180			180		
O_2 av.	%	9.9	10.6		11.2	11.1		10.1	12.4		9.9	11.8	
CO av.	PPM		<0.1			0.6			2			2	
THC av.	PPM		0			0			0			0	
CBs	ng/m³N		9400		17000	7200		5300	3400		5800	2200	
CPs	ng/m³N		28000		23000	21000		10000	8400		5300	4300	
PCDDs		460	260	170	230	220	98	58	77	160	72	12	110
PCDFs	ng/m³N	410	480	60	330	330	44	37	230	30	44	5.1	20
PCDDs+PCDFs	or	870	740	230	560	550	132	95	307	190	116	17.1	130
I-TEQ	ng/g	11.4	13.0	2.30	8.56	9.82	1.74	1.20	6.23	1.17	1.43	0.14	0.92
Co-PCBsTE	ng/m³N		0.74		0.44	0.45	0.069					0.0088	
(Safe[6])	or												
Co-PCBs	ng/g		13.7		8.5	9.0	1.18					0.18	
PCBS			100		104	73	13					8.8	

Table 2. Laboratory Test of Formation with Filter-adhered-ash

	Before Test		200°C, H_2O=0%, HCl=0ppm				200°C, H_2O=2%, HCl=700ppm				130°C, H_2O=2%, HCl=700ppm		
	Ash (20g)		Blank	Gaseous	Ash		Blank	Gaseous	Ash		Gaseous	Ash	
Unit	ng	ng/g	ng	ng	ng	ng/g	ng	ng	ng	ng/g	ng	ng	ng/g
CBs	15800	780	1040	6590	17500	880	1310	6920	19400	980			
CPs	7320	365	83	7110	4280	214	413	34100	6460	324			
T4CDDs	740	37	<0.02	49	760	38	<0.02	63	900	45	22	580	29
P5CDDs	1100	55	0.064	39	1300	65	0.078	41	1200	60	19	1000	50
H6CDDs	2800	140	0.32	57	3200	160	0.31	73	3400	170	24	2200	110
H7CDDs	1800	90	0.42	16	1700	85	0.43	39	1900	95	14	1800	90
O8CDD	1600	80	0.66	5.3	1400	70	0.64	32	1600	80	9.9	1600	80
PCDDs	8040	402	1.464	166.3	8360	418	1.458	248	9000	450	88.9	7180	359
T4CDFs	480	24	0.2	43	560	28	0.31	66	480	24	31	460	23
P5CDFs	540	27	0.47	28	640	32	0.47	83	570	29	41	580	29
H6CDFs	540	27	0.82	18	580	29	0.85	93	550	28	45	620	31
H7CDFs	340	17	0.79	6.3	380	19	0.81	54	350	18	33	400	20
O8CDF	110	5.5	0.24	1.1	100	5	0.26	11	110	5.5	9.9	120	6
PCDFs	2010	100.5	2.52	96.4	2260	113	2.7	307	2060	103	159.9	2180	109
I-TEQ	93.3	4.7	0.08	1.65	95.6	4.78	0.085	9.51	98.5	4.92	4.46	86	4.3

Purpose: to demonstrate the existence of the memory effect from start-up/shutdown; to determine its duration; and to quantify its effect.

Method : water and HCl were mixed within warm air to produce a phenomenon that, as closely as possible, resembles that which occurs in an actual facility. Sampling was done by quickly opening an inspection port on the bottom of the bag house and, with a vacuum cleaner, removing dust adhering on the filter. The dust was then subjected to laboratory testing as is (i.e., without any pretreatment) to investigate the dioxin formation and release capability of the filter-adhered dust itself as influenced by various operating histories (e.g., shutdown on the previous day, etc.).

Laboratory apparatus with experiment conditions are shown in Figure 3; analysis results, in Table 2; and the manner of dioxin formation, in Figure 4.

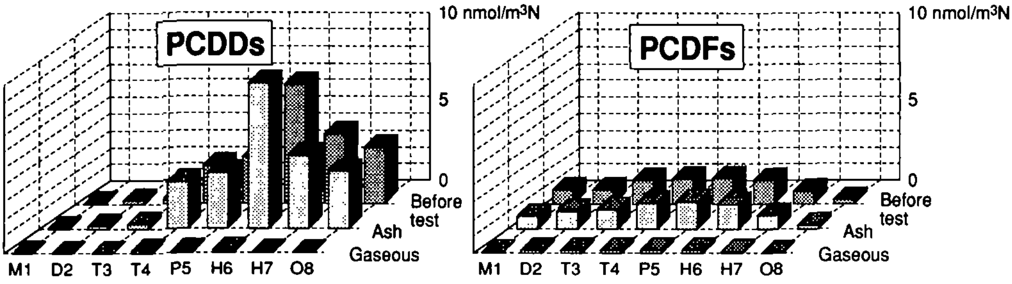

Fig. 4 Change of Congener Pattern with Laboratory Test of Formation with Filter-adhered-ash (20g)
(Ash=20g, t=200°C, HCl=700ppm)

4. Discussion

In facilities, in which the bag house inlet gas temperature is controlled to 190 to 200°C in normal daily operation and which are run for eight hours a day, a considerable memory effect may remain from shutdown the night before or start-up that morning. This can happen even if complete combustion is maintained during steady-state operation. The results of our laboratory tests suggest that, even if the concentration of dioxin at the inlet is zero, it is still possible to detect a concentration on the order of several ng/m3N at the outlet. Converting the dioxin detected as a gas into the actual concentration, we have:

At 700 ppm, 200°C

$$(9.51 - 0.085) \times 0.1 / 0.18 = 5.2 \text{ ng/m}^3 \text{ (I-TEQ)}$$

We reflected the following in the calculation: (a) the actual dust layer thickness was about 1.5 cm, or one-tenth (0.1) of the thickness of the dust in the experiment and (b) the total intake gas volume was 0.18 m^3.

Also, the adhered dust had a dioxin content five times more than the dust of RUN 4. Even so, because the dust was sampled after shut-down, it was not influenced in any way by the subsequent start-up. This means that the memory effect examined in testing is smaller than what is encountered in actual practice.

Our findings suggest that mechanical batch incinerators require not only operational innovations to minimize incomplete combustion during start-up and shutdown, but also other innovations to remove dust from the bag filters. One approach would be to add a thicker precoat of slaked lime *before shutting* down the unit at night so that the highly concentrated dioxins and precursor substances from shutdown/start-up can be quickly removed the next day after trapping.

While sufficient attention must also be devoted to the problem of low-temperature corrosion from acid gas, another possible countermeasure would be to lower the bag house inlet gas temperature. Also, it may be necessary to perform a comparative study of the memory effect by testing at a different facility having an electrostatic precipitator that is operated under 200°C and can be used to reduce the dust residence time.

5. Conclusions

1) In a bag house run at 200°C for eight hours a day, a memory effect from shutdown/start-up remains for several hours into steady-state operation.
2) Dust adhered on the bag filter is influenced by shutdown/start-up and thereby has a higher concentration of PCDDs, PCDFs and precursor substances than does normally collected dust. This in itself has the potential to form and release a fairly large amount of dioxins.

6. References

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