

Removal of Organohalogen Compounds by means of Fabric Filter with Activated Carbon Injection, and Activated Coke

Takaaki Shinoda, Norio Maeda, Isao Maeda, Hirokazu Matsunami & Takayuki Kudo
Takuma Co., Ltd., 2-33 Kinrakuji-cho 2-chome, Amagasaki, Hyogo, 660, Japan

1. Introduction

Ever since it was reported that toxic organohalogen compounds such as PCDDs and PCDFs were emitted from the municipal solid waste (MSW) incineration facilities, every country has been issuing strict limits to the permissible level of such pollutants. Japan this year adopted a new guideline setting the maximum emission level of PCDDs and PCDFs at 0.1ng-TEQ/m³N, thus demanding a high degree of removal technology.

This article reports the results of two experiments we conducted recently, one using fabric filter (FF) with activated carbon injection, and another using activated coke. Both tests successfully maintained the emission level below the new guideline. With the latter experiment, we also investigated the removal efficiency of Co-PCBs, CBs and CPs.

2. Outline of the Experiment Set-up

Figure 1 shows the flow diagram of the test equipment and the sampling points.

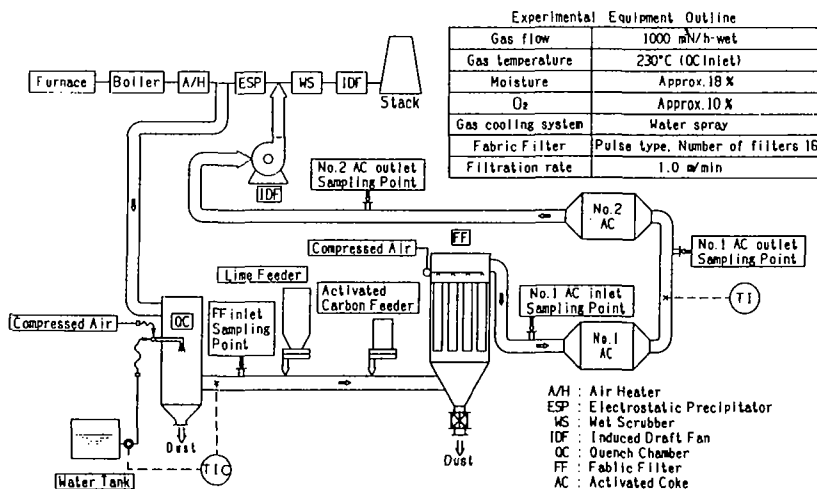


Fig. 1 Process Flow Diagram

Exhaust gas was collected from the electrostatic precipitator (ESP) inlet of a working MSW incinerator, and its temperature was set at pre-determined levels by water spray in the quench chamber. It was sent to the FF for dust removal, then through the coke towers (fixed bed), and was returned to the ESP outlet by an induced draft fan. Two separate coke towers were used so that gas condition between the two towers could be observed.

3. Tests with Fabric Filter with Activated Carbon Injection

3.1. Test Method

We have already reported on the PCDDs and PCDFs removal characteristics when activated carbon was injected into FF together with slaked lime. 1) This time, experiments were done with activated carbon alone, because the dust containing reaction products of slaked lime is not suitable for ash melting. The removal characteristics under this condition were studied.

Activated carbon specified in Table 1 was injected into the FF at the inlet, and was collected along with the dust by the FF. The gas temperatures were set at 210°C, 180°C and 150°C by means of water spray in the quench chamber (QC). Temperature at the QC inlet was approximately 230°C.

Table 1. Typical analysis of Activated Carbon

Name	Steam activated carbon
Base material	Bituminous coal
Particle size	Ave. 20 μm
Specific surface	1050 m^2/g
Pore volume	0.63 m^3/g
Apparent density	0.44 kg/ℓ

3.2. Test Results

Table 2 shows the results of this test, and Figure 2 displays the relationship between the gas temperature at FF outlet and the removal rate of PCDDs/PCDFs.

Table 2. PCDDs/PCDFs, CO data

Run. NO.	Injection chemicals		Gas temp. FFoutlet (°C)	CO QCinlet (ppm) (O ₂ =12%)	O ₂ FFoutlet (%)	PCDDs/PCDFs			
	Activated carbon	Hydrated lime				I-TEQ (ng/m ³ N)			Removal rate (%)
						QCinlet	FFinlet	FFoutlet	
A	-	-	210	157	12.8	-	14	0.20	98.6
B	-	-	180	149	12.8	-	18	0.02	99.9
C	-	-	150	164	13.0	-	25	<0.00	>99.9
D	○	-	210	109	12.4	-	24	0.03	99.9
E	○	-	180	74	12.0	-	28	<0.00	>99.9
F	○	-	150	215	13.5	-	45	<0.00	>99.9
G	-	○	180	103	11.2	20	-	0.04	99.8
H	○	○	180	71	10.7	18	-	0.02	99.9

Dust contents FFinlet 2.0 $\text{g}/\text{m}^3\text{N-dry}$
FFoutlet 0.01~0.02 $\text{g}/\text{m}^3\text{N-dry}$

At this test, the PCDDs/PCDFs concentration at the FF inlet was 14~45 ng-TEQ/m³N, and with the gas temperature of 210°C, uncontrolled concentration exceeded 0.1 ng-TEQ/m³N at the FF outlet. It went down below 0.1 ng-TEQ/m³N only when the temperature was lowered to 180°C. When the activated carbon was injected, the concentration at the FF outlet remained constantly below 0.1 ng-TEQ/m³N across all temperature settings regardless of the concentration at the FF inlet.

Dioxin '97, Indianapolis, Indiana, USA

When the slaked lime was added to the activated carbon, no significant difference was observed in the removal rate. As shown in Figure 3, however, slight increase in the concentration at exit was witnessed.

The results described above confirms that the PCDDs and PCDFs can be removed very efficiently with the injection of activated carbon without slaked lime. This would enable the use of fabric-filter dust for ash melting.

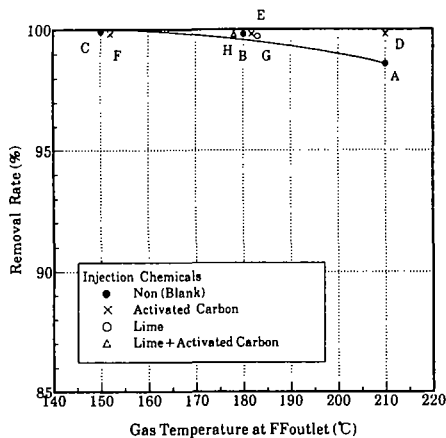


Fig.2 Relationship between Gas Temperatures at FFoutlet and Removal Rate of PCDDs/PCDFs

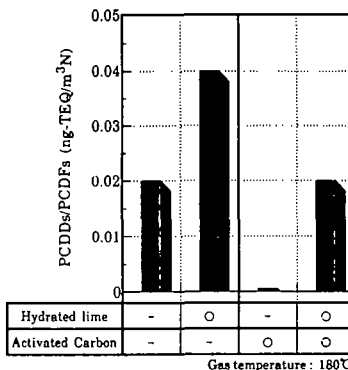


Fig.3 PCDDs/PCDFs(TEQ) at FF outlet according to change of injection chemicals

4. Tests with Activated Coke

4.1 Test Method

The second tests were intended to confirm the fact that removal of organohalogen compounds is possible without activated carbon injection, by the application of activated coke that can be used at a relatively high temperature. Tests were done with the specimens at various temperature levels, as listed below. The specification of the coke used for the tests are listed in Table 3. Some acid gas removal was done in these tests by injecting slaked lime upstream of the FF.

1) Measured Substances:

PCDDs, PCDFs, Co-PCBs, CBs and CPs.

2) Gas Temperatures at No.1 Activated Coke Tower(AC) outlet:

190°C, 180°C, 170°C and 160°C

3) SV values:

No.1 AC inlet~No.1 AC outlet ----- 440 h⁻¹

No.1 AC inlet~No.2 AC outlet ----- 220 h⁻¹

SV Value = Exhaust Gas Volume (m³N/h)/Activated Coke Volume (m³)

Table3. Typical analysis of Activated Coke

Name	Activated coke
Base material	Bituminous coal
Size	Dia. 9.5 mm×10mm
Specific surface	280 m ² /g
Pore volume	0.16 ml/g
Appartment density	0.65 kg/ℓ

4.2. Test Results

Table 4 contains the results of these tests. As for PCDDs and PCDFs, their concentration at AC inlet was low because of the FF located upstream of AC. It was confirmed that the concentration at AC outlet stayed below 0.1 ng-TEQ/m³N regardless of the concentration at the inlet, as long as the gas temperature was kept

below 190°C at the No.1 AC outlet. Figure 4 shows the relationship between the gas temperatures at No.1 AC outlet, and the removal rates of each measured substance at No.1 AC inlet and No.2 AC outlet. As demonstrated, the removal rates generally rose as the temperature went down, except for some variances with CBs.

Table4. PCDDs/PCDFs, Co-PCBs, CBs, CPs data

Run NO.	Gas temp. No.1AC outlet (°C)	PCDDs/PCDFs					Co-PCBs				
		I-TEQ (ng/m ³ N)			Removal rate (%)		TEQ (ng/m ³ N)			Removal rate (%)	
		No.1AC inlet	No.1AC outlet	No.2AC outlet	No.1AC inlet-No.1AC outlet	No.1AC inlet-No.2AC outlet	No.1AC inlet	No.1AC outlet	No.2AC outlet	No.1AC inlet-No.1AC outlet	No.1AC inlet-No.2AC outlet
1	189	0.25	<0.00	0.08	>99.9	68.0	0.04	0.01	0.01	75.0	75.0
2	177	0.05	<0.00	<0.00	>99.9	>99.9	0.01	<0.00	0.01	>99.9	—
3	168	0.06	<0.00	<0.00	>99.9	>99.9	0.01	<0.00	<0.00	>99.9	>99.9
4	156	<0.00	<0.00	<0.00	—	—	0.01	<0.00	<0.00	>99.9	>99.9

Run NO.	Gas temp. No.1AC outlet (°C)	CPs					CBs				
		Concentration (ng/ℓN)			Removal rate (%)		Concentration (ng/ℓN)			Removal rate (%)	
		No.1AC inlet	No.1AC outlet	No.2AC outlet	No.1AC inlet-No.1AC outlet	No.1AC inlet-No.2AC outlet	No.1AC inlet	No.1AC outlet	No.2AC outlet	No.1AC inlet-No.1AC outlet	No.1AC inlet-No.2AC outlet
1	189	2.2	1.8	0.07	18.2	96.8	1.2	0.93	1.1	22.5	8.3
2	177	5.9	0.44	0.05	92.5	99.2	11	1.3	0.58	88.2	94.7
3	168	6.6	0.04	0.16	99.4	97.6	11	1.9	ND	82.7	>99.9
4	156	0.64	0.05	ND	99.2	>99.9	1.1	0.7	0.2	36.4	81.8

Figure 5 shows the relationship between No.1 AC outlet temperatures and concentrations of each substance at various sampling points. TEQ values of Co-PCBs were obtained by using TEF proposed by Dr. Safe. 2) In general, it seems all substances are removed at No.1 AC, showing low concentrations at No.1 AC outlet. As mentioned, lower temperature induces lower concentration at the outlet, except in the case of CBs that showed varied results due to its low boiling point. This also seems to indicate that the removal of these substances by coke is mainly through adsorption. However, a few data did indicate higher concentration at No.2 AC outlet than No.1, and lowering the SV value did not improve the removal efficiency. Incidentally, we have confirmed that the activated coke used for this test improves its desulfurization and deNO_x effects as the SV value is reduced. We feel that in future studies it is necessary to determine the optimum SV value with this fact in mind.

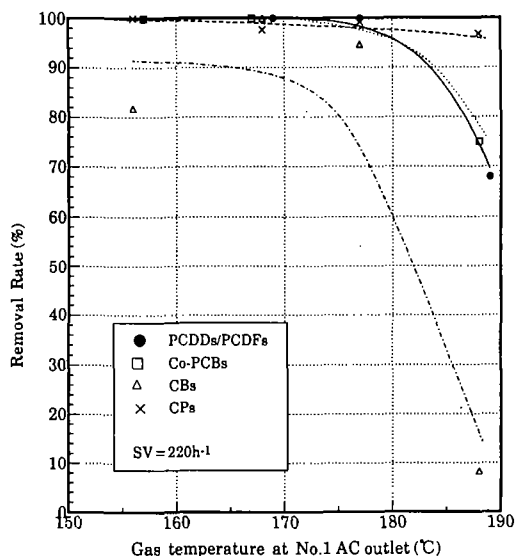


Fig.4 Relationship between Gas Temperatures at No.1 AC outlet and Removal Rate

Dioxin '97, Indianapolis, Indiana, USA

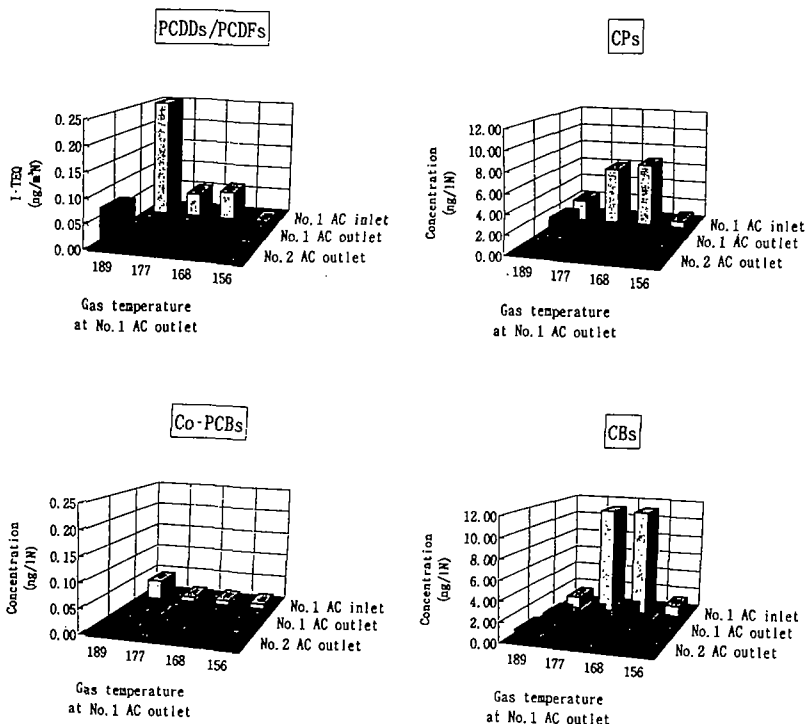


Fig. 5 Concentration at each sampling point

5. Conclusion

The following conclusions have been reached from the results described above.

- 1) Fabric filters, with the injection of activated carbon only, can achieve a stable emission below $0.1 \text{ ng-TEQ/m}^3 \text{N}$ at gas temperatures within $150^\circ\text{C} \sim 210^\circ\text{C}$ range. Eliminating the use of slaked lime makes the fly ash collected by the FF suitable for ash melting.
- 2) Activated coke tests have revealed that each substance is influenced by the gas temperature; as the temperature is lowered, the removal rate improves. It is entirely possible to maintain the emission rate of PCDDs/PCDFs below $0.1 \text{ ng-TEQ/m}^3 \text{N}$ by combining the use of FF and AC.
- 3) It has also been discovered that in addition to PCDDs/PCDFs, Co-PCBs, CBs and CPs can be removed at relatively high temperatures by the use of activated coke.

6. References

- 1) H. Tejima, I. Nakagawa, T. Shinoda, I. Maeda: A simple way to remove PCDDs/PCDFs in Refuse Incineration Plants. DIOXIN'94, Vol. 19, p371-375 (1994).
- 2) S. Safe, C. Yao and D. Davis: Development of Toxic Equivalency Factors for Polychlorinated biphenyls (PCBs), DIOXIN'90, Vol. 2, p55-59 (1990).