Dioxin Removal and Decomposition with Moving Bed Activated Carbon Adsorption Tower and Regenerator

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Introduction

In Japan the concentration of dioxins in exhausted gas from the newly-built waste treatment plants is regulated below 0.1 ng-TEQ/m^3N, and at the same time it is aimed that the concentration of dioxins in the bottom ash and fly ash from those plants is also reduced.

The Japan Waste Research Foundation has been conducting "Research on generation and behaviors of dioxins in waste treatment (FY 1997 to 1999)." As one of themes of this research, an investigative test was conducted at the plant for dioxins removal and decomposition technique with the moving bed activated carbon adsorption tower having an activated carbon regenerator incorporated in the system to confirm its performance.

As the removal system for dioxins from exhausted gas, the activated carbon adsourption tower is very effective. However, a big problem of this system is the method of treatment of used activated carbon. Accordingly, we decided to develop and confirm this moving bed system, in which used activated carbon was regenerated and adsorbed dioxins were decomposed.

The basic part of this system was developed by Sumitomo Heavy Industries, Ltd. in 1960s for desulfurization of flue gases, and has long been carrying out stable adsorption and regeneration using activated carbon. As a desulfurizer equipped with a steelmaking mill, this desulfurizer, which is capable of treating the world's largest volume of flue gases (900,000 m^3N/h), has been in successful operation since 1987. Research has also been conducted since 1996 on the application of this system for the removal of dioxins from municipal waste incinerator flue gases, with the result that decomposition of dioxins in the regeneration process of activated carbon was confirmed through laboratory tests and bench scale tests.[1)]

Materials and Methods

In the existing refuse incinerator facility (30 t/24 h), this system that is capable of treating the total volume of its flue gases was additionally installed in front of a stack. The flow sheet and sampling positions are given in Fig. 1.

In the adsorption tower, there is an activated carbon layer divided into three parts which move down at different speeds while flue gases flow horizontally across the activated carbon layer (Fig. 2).The regeneration tower is internally purged with N_2 gases to prevent the combustion of activated carbon. Carrier gas makes this tower N_2 atmosphere. Here, used activated carbon is regenerated. Besides, within carrier gas a few ammonia is added in order to help the regeneration of activated carbon. After going through this tower, off gas is backed before bag house. The inside of this tower is then heated to 400 to 450°C, held at this temperature for 2 to 4 hours and finally cooled down (Fig. 3).

The investigative test was conducted five months after the commencement of gas feed. At this time, the activated carbon has repeated regeneration three times.

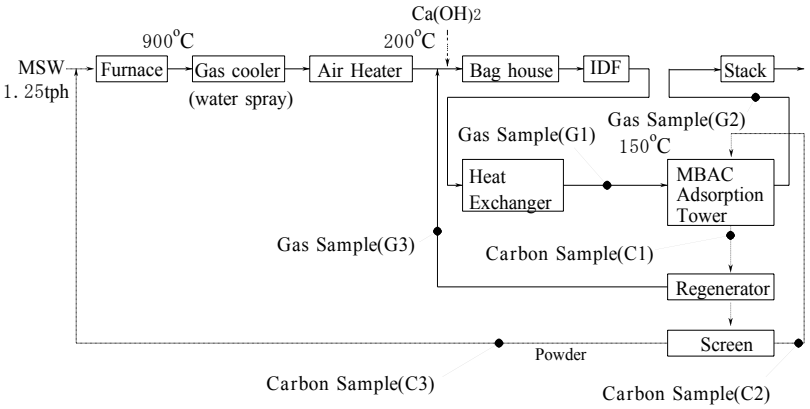

Fig. 1 Process flow diagram

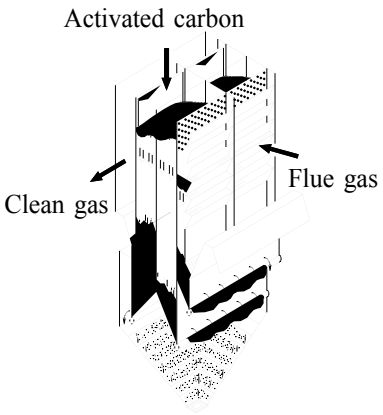

Fig. 2 MBAC adsorption tower
(MBAC: moving bed activated carbon)

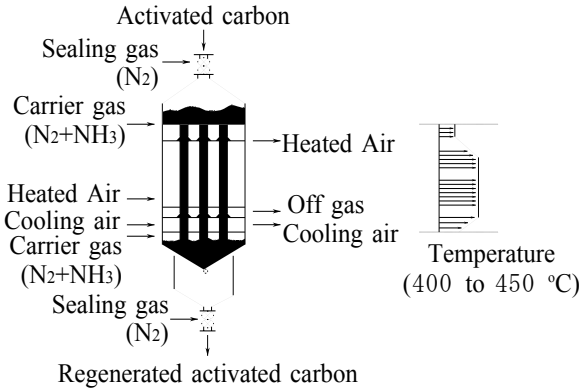

Fig. 3 Regenerator

Results and Discussion

The results of flue gas analysis are given in Table 1. The removal rate of dioxins was, as shown in Table 2, 99.9% or higher both for each homologue and for the value converted to toxicity equivalent.

Table 1. Flue Gas Analysis Data (data with * : converted to O_2=12%)

Item	Unit	Adsorption Inlet (G1)	Adsorption Outlet (G2)	Regenerator Outlet (G3)
Wet gas flow rate	m^3N/h	11,400	11,500	25
Dry gas flow rate	m^3N/h	8,130	7,800	23
Temperature	°C	151	150	343
O_2	%	11.8	14.3	0.8
Dust	mg/m^3N	8*	<1*	0.1*
SOx	ppm	8*	<1*	1,100
NOx	ppm	63*	52*	<10
HCl	mg/m^3N	7*	8*	510
PCDDs/DFs	$ng\text{-}TEQ/m^3N$	18*	0.016*	0.031*

Table 2. PCDDs/DFs Removal rate

Item	Adsorption Inlet (G1)	Adsorption Outlet (G2)	Removal rate [%]
T_4CDDs	99	N.D.	>99.9
P_5CDDs	47	N.D.	>99.9
H_6CDDs	2.2	N.D.	>99.9
H_7CDDs	0.82	N.D.	>99.9
O_8CDD	0.53	N.D.	>99.9
PCDDs	150	N.D.	>99.9
T_4CDFs	1,400	0.57	99.9
P_5CDFs	800	0.46	99.9
H_6CDFs	14	N.D.	>99.9
H_7CDFs	0.13	N.D.	>99.9
O_8CDF	N.D.	N.D.	>99.9
PCDFs	2,200	1.0	99.9
I-TEQ	18	0.016	99.9

(unit : ng/m^3N converted to O_2=12%)

Table 3. Activated Carbon Analysis Data

Item	Regenerator Inlet (C1)	Regenerator Outlet (C2)	Regenerator Outlet/powder (C3)
T_4CDDs	64	0.16	3.4
P_5CDDs	56	0.12	3
H_6CDDs	16	0.1	1.8
H_7CDDs	3.8	0.049	0.64
O_8CDD	0.5	0.021	0.29
PCDDs	140	0.45	9.1
T_4CDFs	220	0.35	23
P_5CDFs	130	0.27	14
H_6CDFs	41	0.18	5.5
H_7CDFs	10	0.076	1.5
O_8CDF	0.77	0.015	0.24
PCDFs	400	0.89	44
I-TEQ	7.0	0.021	0.93

(unit : ng/g)

(N.D. : Not Detected)

Table 4. Mass balance and decomposition rate in Regenerator (unit : μg/h)

Item	INPUT	OUTPUT				Decomposition	
	Regenerator Inlet (Cl)	Regenerator Outlet (C2)	Regenerator Outlet/powder (C3)	Regenerator Outlet/Gas (G3)	Total (TO)	(Cl-TO)	Rate (Cl-TO)/(Cl) [%]
Flowrate	20 kg/h	19.9 kg/h	0.1 kg/h	23 m^3N/h			
PCDDs	2,806	9.0	0.91	0.013	10	2,796	99.6
PCDFs	8,040	17.8	4.42	0.067	23	8,017	99.7
I-TEQ	140	0.42	0.093	0.0016	0.5	139.5	99.6

Table 5. Flue Gas Analysis Data on another day with Co-PCBs (unit : ng/m^{3}N)

Item	Adsorption Outlet (G2)	Regenerator Outlet (G3)
PCDDs/Fs (TEQ with TEF-'88)	0.042	0.026
Co-PCBs (TEQ with TEF-'97)	0.0003 (0.7%)	0.0001 (0.3%)
PCDDs/Fs (TEQ with TEF-'97)	0.0414	0.0258
Total TEQ (with TEF-'97)	0.0417	0.0259

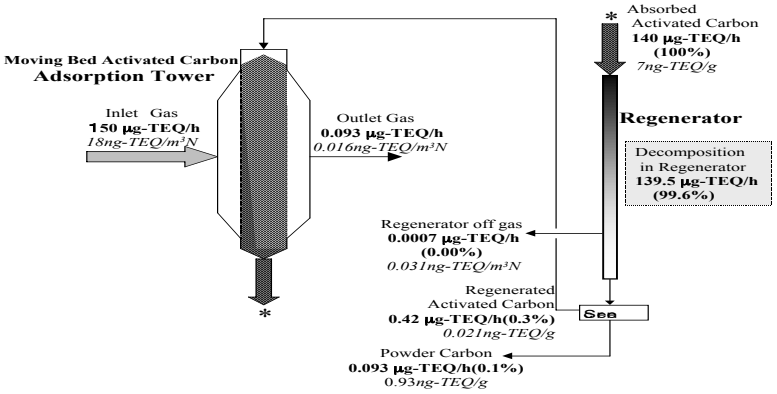

Fig. 4 Mass balance and decomposition rate in Regenerator

The results of activated carbon analysis are given in Table 3. As is clear from this table, dioxins have been decomposed in the regeneration process of activated carbon in the regeneration tower. The decomposition rate determined from the mass balance calculation was 99% or higher both for PCDDs/Fs and for the value converted to toxicity equivalent, as shown in Table 4. The mass balance of dioxins is shown in Fig. 4. In Fig. 4, the adsorption tower input determined from the product of flue gas volume and concentration, and the adsorption tower output determined from the product of activated carbon moving rate and concentration are indicated. These two values are well-balanced, although, taking into consideration the significant difference in concentration variations and residence time (= difference in time zones represented by the measured values), these values are naturally not much more than the measure of comparison in the highest figure.

We measured PCDDs/Fs and Co-PCBs on another day (Table 5). Contribution of Co-PCBs to TEQ is 0.3% and 0.7% in this case.

Acknowledgment

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References

1) Watanabe T., Tanaka T. and Yamazaki M.: Dioxin removal system using activated carbon in circulation, Fundamentals of Adsorption 6, International Adsorption Society, Gien, France

(May 24 - 28, 1998).