JFE TECHNICAL REPORT
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High Efficiency Activated Carbon Adsorber "JFE-Gas-Clean-DX"†

1. Introduction

The current regulatory values applied to dioxins under Law Concerning Special Measures against Dioxins are 0.1 ng-TEQ/m^3-norm. or under for dioxins in flue gas discharged by waste incinerators and 0.5 ng-TEQ/m^3-norm. or under for dioxins from electric furnaces for steelmaking. Equipment which can reduce dioxins emissions to lower concentrations than the current regulatory values while maintaining stable performance is also demanded. Moreover, with continuing attention focused on reducing releases of mercury (Hg), there is also an increasing need for equipment that enables collective removal also including Hg.

To meet the need for removal of trace amounts of harmful substances, until now JFE Engineering had installed moving bed-type activated carbon adsorber. Since flue gas passes through activated carbon having a certain bed thickness in a moving bed-type activated carbon adsorber, these systems demonstrate excellent removal performance for trace amounts of harmful substances. However, there were also problems with this method, including the large size of the equipment, the large amount of activated carbon used, etc.

To overcome these problems, JFE Engineering developed and commercialized a compact, high efficiency activated carbon adsorber, trade-named "JFE-Gas-Clean-DX," in which activated carbon is packed in an activated carbon cartridge with a fixed bed & lateral flow-type structure, thereby realizing efficient contact between the flue gas and the activated carbon[1]. This report describes the features of the device and its performance in actual plant.

2. Outline and Features

Figure 1 shows a schematic illustration of the appearance of the device; **Fig. 2** shows a schematic diagram of the activated carbon cartridge. The device consists of an easily detached/installed activated carbon cartridge in the device housing. High efficiency contact between the flue gas and activated carbon is realized by adopting a fixed bed & lateral flow type structure. A new granular activated carbon with excellent ignition resistance performance was also developed and applied in this device. The main features of the device are as follows:

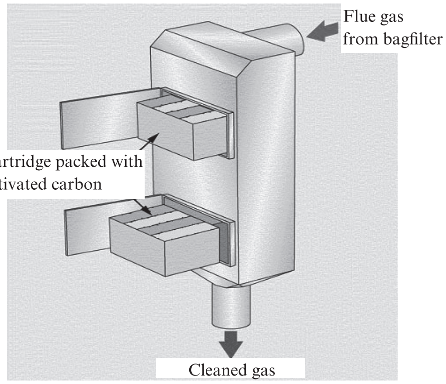

Fig. 1 Schematic illustration of activated carbon adsorber

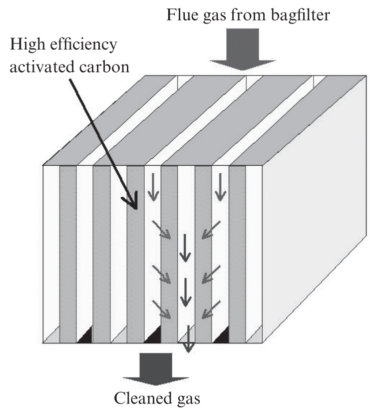

Fig. 2 Cartridge packed with activated carbon

(1) Compact size
(2) High removal performance for trace amounts of harmful substances
(3) Low pressure loss
(4) Can be used at high temperatures (Maximum flue gas temperature: 200°C)

As shown in Fig. 2, flue gas is uniformly dispersed as it passes through the multiple thin packed layers of activated carbon installed in the activated carbon cartridge. As a result, contact efficiency between the activated carbon and trace harmful substances in the flue

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gas is excellent, and high removal performance and a large decrease in activated carbon use are possible. When dioxins are the object substance to be removed from waste incinerator flue gas, the device supports a space velocity (SV) on the order of 10 000 h^{-1}, and as a result, carbon use is 1/20 to 1/10 of that with the conventional moving bed-type activated carbon adsorber (SV = 500–1 000 h^{-1}).

As an additional advantage, because thin layers of activated carbon are used, pressure loss is low in comparison with the conventional moving bed-type activated carbon adsorber, which has pressure loss of approximately 2–3 kPa. Because the pressure loss is no more than 0.5 kPa per activated carbon cartridge stage, the load on the flue gas fan is also low, and electric power consumption can be held to a low level.

To prevent dust from clogging the packed bed of activated carbon, the basic method when applying this device is installation in the after stage of the bag filter. For this reason, activated carbon with high ignition prevention performance is used, enabling treatment up to a maximum service temperature of 200°C, which is the temperature of general bag filters. Accordingly, application at the outlet of the bag filter at waste incinerators is fully possible.

3. Performance in Actual Facilities

3.1 Actual Operating Conditions

The delivery record of this device and the operating conditions at the actual plant are shown in **Table 1**. The delivery record includes a waste incinerator, ash melting furnace, and electric furnace for steelmaking. Although the gas volume, gas temperature, and other conditions are different at each facility, since the SV at two of these facilities is more than 10 000 h^{-1}, it can be understood that the amount of activated carbon used per unit of gas is extremely small.

3.2 Dioxins Removal Performance

Table 2 shows the results of measurements of dioxins at the inlet and outlet of the activated carbon adsorber at the actual facilities. Depending on the plant, the inlet concentration varies from 1.1 to 5.5 ng-TEQ/m^3-norm. However, in all cases, removal efficiency exceeds 99%, achieving extremely high removal efficiency independent of the inlet concentration. Particularly at the steelmaking electric furnace, in spite of the extremely high SV value of 28 000 h^{-1}, the outlet concentration was 0.009 3 ng-TEQ/m^3-norm. and removal efficiency was 99.8% or higher, showing outstanding dioxins removal performance.

As the result of an evaluation of activated carbon life, **Fig. 3** shows the relationship between the number of months after the start of equipment operation and dioxins removal efficiency. As removal efficiency of more than 99% was being maintained after 16 months at the ash melting furnace and after 18 months at the steelmaking electric furnace, the activated carbon displays a satisfactory service life, irrespective of the use of a fixed bed and the compact size of the device.

Table 1 Operating conditions of activated carbon adsorber

	Waste furnace	Ash melting furnace	Electric furnace for steel
Gas volume (m^3-norm./h)	31 000	5 700	287 000
Gas temperature (°C)	140	170	90
SV (h^{-1})	11 000	2 600	28 000
Removal material	Dioxins, Hg	Dioxins, Hg	Dioxins

Table 2 Dioxins concentrations at activated carbon adsorber

	Dioxins concentrations (ng-TEQ/m^3-norm.)		Removal-efficiency (%)
	Inlet	Outlet	
Electric furnace for steel	5.5	0.009 3	99.83
Ash melting furnace	1.8	0.000 80	99.96
Waste furnace	1.1	0.000 16	99.99

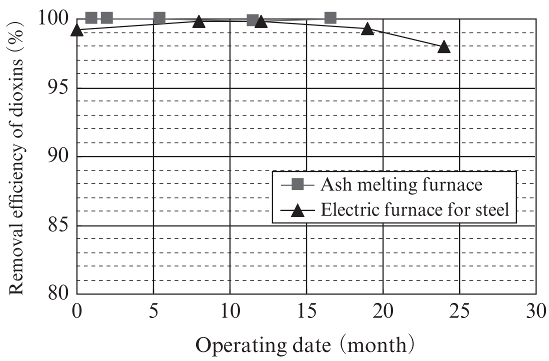

Fig. 3 Transition of dioxins removal efficiency

3.3 Hg Removal Performance

Table 3 shows the results of measurements of Hg at the inlet and outlet of the activated carbon adsorber at the waste incinerator and ash melting furnace. At both plants, the outlet concentration is under the minimum determination limit (<0.005 mg/m^3-norm.), showing

Table 3 Hg concentrations at activated carbon adsorber

	Inlet (mg/m^3-norm.)	Outlet (mg/m^3-norm.)
Waste furnace	0.065	<0.005 (Under determination limit)
Ash melting furnace	0.57	<0.005 (Under determination limit)

high removal performance. The Hg concentrations under the minimum determination limit were being maintained after 6 months at the waste incinerator and after 16 month at the ash melting furnace, showing that the device also has satisfactory activated carbon life in treatment of Hg.

4. Conclusion

A compact, high efficiency activated carbon adsorber, “JFE-Gas-Clean-DX,” was developed and applied practically. In this device, high contact efficiency between flue gas and the packed bed of activated carbon is realized by adopting a fixed bed & lateral flow structure. As a result, the device satisfies both high performance in removal of trace amounts of harmful substances and compact equipment size. The device has been installed at three facilities, i.e., a waste incinerator, an ash melting furnace, and an electric furnace for steelmaking. The following performance has been obtained in application to these actual facilities.

(1) At the waste incinerator, ash melting furnace, and steelmaking electric furnace, the device displayed excellent removal performance, with dioxins removal efficiency exceeding 99%, in spite of high space velocity (SV) conditions.

(2) At the ash melting furnace and steelmaking electric furnace, high dioxins removal performance was maintained for 16 months and 18 months, respectively, demonstrating satisfactory activated carbon life.

(3) The Hg concentration at the adsorber outlet at the waste incinerator and the ash melting furnace was under the minimum determination limit (<0.005 mg/m^3-norm.), and high Hg removal performance was being maintained at these facilities after 6 months and 16 months, respectively, showing ample activated carbon life.

Because this device is applicable not only to dioxins and Hg, but also volatile organic compounds (VOC), persistent organic pollutants (POPs, i.e., residual organic compounds such as hexachlorobenzene, etc.), malodorous components, etc., intends to further expand its range of applications in the future.

Reference

1) Hirayama, A. et al. Proceedings of the 21th Annual Cnference of Japan Society of Material Cycles and Waste Management. 2010, p. 383–384.

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