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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 fue 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 fue gas passes through activated carbon having a certain bed thickness in a moving bed-type activated

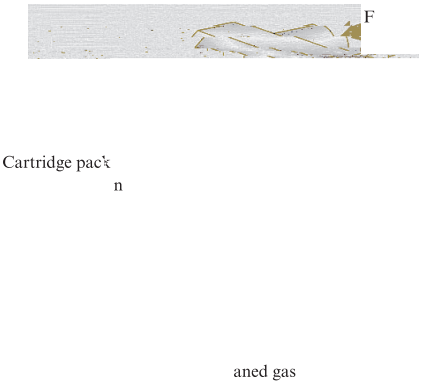

Fig. 1 Schematic illustration of activated carbon adsorber

oped and commercialized a compact, high effciency activated carbon adsorber, trade-named "JFE-Gas-Clean-DX," in which activated carbon is packed in an activated carbon cartridge with a fxed bed & lateral fow-type structure, thereby realizing effcient contact between the fue 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 effciency contact

Fig. 2 Cartridge packed with activated carbon

between the fue gas and activated carbon is realized by adopting a fxed bed & lateral fow 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:

(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 fue gas temperature: 200°C)

As shown in Fig. 2, fue 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 effciency between the activated carbon and trace harmful substances in the fue

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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 fue 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 fue 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 flter. 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 flters. Accordingly, application at the outlet of the bag flter 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 effciency exceeds 99%, achieving extremely high removal effciency 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 effciency was 99.8% or higher, showing outstanding dioxins removal performance.

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-effciency (%)
	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

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 effciency. As removal effciency 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 fxed bed and the compact size of the device.

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)