Removal of Dioxins and Furans with Activated Carbon Counter-current Flow Process

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1. Introduction

The Federal Republic of Germany and Republic of Austria, as well as the Netherlands, Sweden and other European countries have stipulated stringent emission values for dioxins and furans in their clean air act laws. The emission of these pollutants have to be lower than 0.1 ng/Nm³ for hazardous and industrial municipal waste incinerations.

Based on these emission values, new technologies for the removal of dioxins and furans have been developed in the past years and have been installed in the flue gas cleaning systems of the waste treatment plants. In Austria, one of the most advanced technologies, the WKV/Integral counter-current activated coke process, is installed behind hazardous and industrial waste incineration plants, and has been in continuous operation for 2 years. The results of this technology are described in this report.

2. Description of the counter-current flow process

The counter flow process is a dry flue gas cleaning procedure. Activated carbon is used as an adsorption agent for the flue gas cleaning. Depending on the task set, activated carbon from hard coal or lignite coal, varying in granule sizes and varying in adsorption qualities can be used. For flue gas cleaning behind municipal refuse incineration plants, activated coke from brown coal with a granule size of 1.25 mm to 5 mm with a specific surface of approx. 300 m²/g is used.

The counter flow adsorber functions according to the principle of the moving bed technique. In this technology the flue gas to be cleaned flows vertically through the activated carbon bed from bottom to top, and the activated carbon migrates vertically through the adsorber from top to bottom. As a result of the extraordinary low velocity of carbon migration, the lingering period of activated carbon in the adsorber can amount to as much as 1 year. The counter flow adsorber technology is also characterized as a stationary bed adsorber.

The flue gas to be cleaned has an inlet temperature of approx. 120°C to 165°C. The flue gas is lead to the adsorber gas collecting room underneath the gas distribution grid. After flowing through the activated carbon bed, the cleaned flue gas leaves the adsorber via a gas collecting room above the activated carbon bed and is lead to the stack.

The construction of the gas distribution grid in the adsorber guarantees a uniform distribution of flue gas and a constant gas velocity across the cross-section of the activated carbon bed, as well as an absolute plane-parallel discharge of spent activated carbon. The discharge device is situated below the distribution grid at the bottom of the adsorber which enables the discharge of spent activated carbon during operation. While discharging activated carbon, the carbon bed is lowered in 3 mm steps. To maintain a constant activated carbon bed height, the adsorber is constructed in such a manner that fresh activated carbon flows directly from an integrated fresh coke bunker in the top part of the adsorber on to the top of the adsorber bed.

While flowing through the activated carbon bed, the gaseous pollutants are adsorbently bound in the pore system of the activated carbon granules. Since the activated carbon bed acts simultaneously as a dust filter, the fly ash in the flue gas is retained in the carbon bed within the first few millimeters above the distribution grid. Due to the high adsorption capacity and adsorption speed of pollutants on activated carbon, the pollutants are adsorbed immediately above the combined gas distribution and discharging grid. By operating the discharge device, only activated carbon with the highest pollutant load is discharged. Using the counter flow principle, the maximum loading capacity of the activated carbon is exploited, minimizing the consumption of adsorbants.

3. Capacity of counter-current adsorbers

Adsorber plants with a gas volume flow of up to 160,000 m^3/h (s.a.c.)[1)] per adsorber are in operation for the different areas of application - from the cleaning of chemical process gases to flue gas cleaning behind municipal and hazardous refuse incineration plants. Adsorbers having large gas volume flow rates are designed in a module form. In this respect, approx. 20,000 m^3/h (s.a.c.) flow through each module. The number of modules integrated in the adsorber is selected according to the maximum gas flow and operating conditions. The modules are integrated in the adsorber and can be arranged beside or on top of each other, depending on the area available for the installation of the adsorber.

4. Reference plant for the counter-current flow adsorbers

Flue gas cleaning plants are functioning worldwide using the counter-current flow process, with a total volume flow of approximately 2,8 mio m^3/h. An example of this is the company **"Entsorgungsbetriebe Simmering (EbS)"** in Vienna, the only incineration plant for industrial and hazardous waste in Austria, where 5 counter-current flow adsorber units have been installed behind the incineration units and have been in continuous operation since 1992.

The plant was designed and built by the Austrian company **INTEGRAL ENGINEERING** together with **WKV**.

Following capacities are installed:

Rotary kiln incineration: DRO 1[2] (industrial/hazardous waste):	flue gas quantity	126,500 m^3/h (s.a.c.)
Rotary kiln incineration: DRO 2 (industrial/hazardous waste):	flue gas quantity	126,500 m^3/h(s.a.c.)
Fluidized bed incineration: WSO 1[3] (sewage sludge):	flue gas quantity	68,500 m^3/h(s.a.c.)
Fluidized bed incineration: WSO 2 (sewage sludge):	flue gas quantity	68,500 m^3/h(s.a.c.)
Fluidized bed incineration: WSO 3 (sewage sludge):	flue gas quantity	74,000 m^3/h(s.a.c.)

Each adsorber behind the rotary kilns consists of 8 modules, and each adsorber behind the fluidized beds have 4 modules. The velocity of migration of the activated carbon bed amounts to approx. 5 mm/day - this corresponds to an activated carbon consumption of approx. 500 t annually for the entire plant. The operation of the flue gas cleaning plant was designed to be extensively automated, so that no additional staff had to be employed. Since the start-up of operation and commissioning, the plants have been in continuous operation and are functioning perfectly. The emission values of the pollutants behind the adsorbers are far lower than the limit values by law and even far below the guaranteed values stipulated in the contract.

The spent activated coke is incinerated in the fluidized incineration plant so that no carbon residue has to be landfilled. The adsorbed dioxins/furans are burnt in the incineration process.

Table 1 illustrates the emission values behind the rotary kiln and fluidized bed adsorbers. These values were measured by the local Austrian authorities during the official acceptance of the plant, and are now continuously registered by permanent measuring devices installed in the flue gas stack behind the adsorbers. Since the start-up of the plants, no emission values have exceeded the stipulated emission values in the clean air act.

TABLE 1: EMISSION VALUES BEHIND COUNTER-CURRENT FLOW ADSORBERS

Pollutants		Emission values		Austrian
		Fluidized bed	Rotary kiln	Emission limits
Sulphur dioxide	mg/m³	0. 9	8. 5	50. 0
Hydrogen chloride	mg/m³	1. 4	2. 7	10. 0
Hydrogen fluoride	mg/m³	<0. 2	0. 1	0. 7
Dust	mg/m³	<0. 2	<0. 3	15. 0
Mercury	mg/m³	<0. 0021	<0. 0008	0. 05
Cadmium	mg/m³	0. 0007	0. 0134	0. 05
Chrome	mg/m³	0. 0004	0. 0001	2. 0
Lead	mg/m³	0. 0003	0. 0009	
Zinc	mg/m³	0. 004	0. 0006	
Arsenic	mg/m³	<0. 0004	0. 0081	0. 5
Nickel	mg/m³	<0. 0001	0. 0001	
Cobalt	mg/m³	<0. 0002	0. 00009	
Dixons/Furans	**mg/m³**	**0. 015**	**0. 018**	**0. 1**

All values in Table 1 refer to dry flue gas, at 1013 mbar, 0°C and are half hour mean valu

Dioxins and furans refer to ITEF (International Toxicity Equivalency Factors)

1) s.a.c. Standard atmospheric condition
2) DRO Rotary kiln incinerator
3) WSO Fluidized bed incinerator

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