Dioxin Removal from Wet Phase Flue Gas Treatment with Powdered Activated Carbon

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Introduction

Every year enormous amounts of municipal waste are produced. The caloric value of a large fraction of the waste is utilised on a large scale in municipal waste incinerators for the production of energy. Besides energy production, incineration of waste also reduces the volume of the waste, which is particularly important in densely populated areas. Whereas the waste incinerators at first consisted of an oven and a stack only, currently a sophisticated flue gas cleaning installation is required to reduce the emission of harmful compounds.
Originally, the main compounds that had to be removed from the flue gas were dust (fly ash), and acid gasses (e.g., HCl and SO_2). For the removal of fly ash commonly electrostatic precipitators (ESP) or fabric filters (FF) are used. Acid gasses are mostly removed either in a (semi-)dry system with spray dryer adsorbers (SDA), or in wet systems using wet scrubbers. Large numbers of flue gas cleaning installations have been build containing these basic components.
Today, the emission of other harmful compounds , e.g., NO_x, dioxins/furans, is also to be reduced. Extensions to the existing flue gas cleaning installations are required to satisfy the new demands. A generally accepted proven technique for the removal of dioxins is activated carbon injection (ACI), often in combination with SDA. With this technique powdered activated carbon (PAC) is injected into the gas stream as a dry powder, or as a slurry, alone or combined with other additives (e.g. lime in SDA). In subsequent parts of the flue gas cleaning system the loaded PAC is removed from the gas stream with an ESP or FF. Particularly the flexibility and low investments of ACI makes it a favourite supplement to both existing and new flue gas cleaning installations. Examples of this solution have been presented previously (1). For this application special PAC types are available in the market, e.g., NORIT GL 50, and Darco FGD.
More recently, results have become available of ACI in combination with wet scrubbers. This lecture will present some recent NORIT experiences with this combination for three cases.

PAC application in wet scrubber systems

This application involves the dosing of PAC in the flue gas and/or in the wash water of the wet scrubber. The PAC adsorbs the organic dioxins both in the gas phase and in the liquid phase, since by nature PAC is somewhat hydrophobic. The loaded PAC is separated from the liquid in the waste water treatment installation. Special carbon types are available for this application, e.g., NORIT SA Super and NORIT GLS 20.

Incinerator A (2)

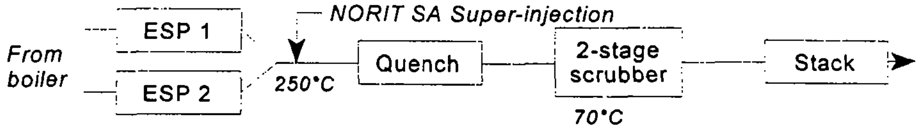

Figure 1 Schematic representation of the flue gas cleaning installation of Incinerator A.

In Incinerator A municipal waste is combusted in two lines, producing 76000 Nm^3/h flue gas in total. A schematic drawing of its flue gas cleaning installation is presented in figure 1. Initially, after installing the wet scrubber without ACI, the dioxin emission level was low, however, gradually it increased up to unacceptable levels. It was decided to expand the flue gas cleaning installation with ACI. The wet scrubber was in use for about 2½ years before a NORIT PAC-dosing installation was installed in front of the quench. The dosed NORIT SA Super is separated from the flue gas in the wet scrubber, therefore no additional investments for a FF was required. After starting the PAC dosing it took about 6 months before the dioxin emission levels were acceptable, due to the so-called "memory effect" in the scrubber. The "memory effect" stands for the initial low dioxin removal efficiency observed after starting ACI in existing installations. It has been observed that initially the dioxin concentration in the flue gas entering the scrubber can be lower than that at the tail-end of the scrubber. The reason for this is desorption of dioxins from the lining of the scrubber, which accumulated there during the preceding period. The addition of PAC to the scrubber contributes to a decreased life time of the "memory effect". Therefore, in Incinerator A the PAC dosing rate was initially kept at 150 mg PAC/Nm^3. After about 6 months the dosing was optimized to 80 mg PAC/Nm^3, and today a dosing rate of 30 mg/Nm^3 leads to satisfying results. In table 1 the latest results are represented.

Table 1 Current situation in Incinerator A.

PAC grade		NORIT SA Super
Temperature dosing point	°C	250
Temperature in scrubber	°C	70
Dioxin inlet concentration	ng TEQ/Nm^3	2-5
Dioxin outlet concentration (stack)	ng TEQ/Nm^3	< 0.1

Incinerator B (3)

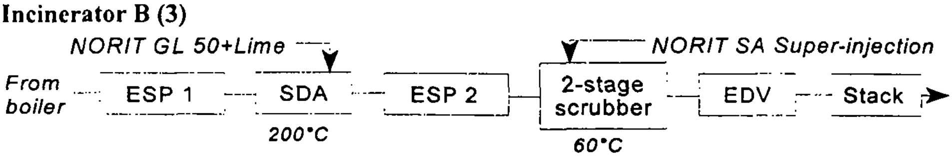

Figure 2 Schematic representation of the flue gas cleaning installation of Incinerator B.

Incinerator B consists of four municipal waste incineration lines, producing 165000 Nm^3/h flue

gas in each line. Initially the flue gas cleaning installation consisted of an ESP, and a SDA+ESP. Due to aggravated emission limits for dioxins the installation was extended with ACI in combination with the existing SDA (using NORIT GL 50), and with a two-stage scrubber + electrodynamic Venturi (EDV). During the first year after start-up it remained a problem to comply with the dioxin emission limit. One of the measures taken was to add NORIT SA Super to the wash water of the scrubber. During the first tests up to 60 g PAC/l wash water was added, which resulted in a decrease of the dioxine content in the flue gas over the scrubber of about 75 %.
In the second year of operation more tests were performed, during which also the dioxin concentration in the used wash water was analyzed. During normal operation, i.e., without PAC in the wash water, the dioxin removal rate through the used wash water was about 1 µg dioxins/h. When 1 g/l NORIT SA Super was dosed in the wash water, the dioxin removal rate increased to 70-140 µg/h as a result of accumulation of dioxins onto the PAC. The indicated PAC concentration in the wash water equals about 15 mg PAC/Nm^3 in the flue gas. Evaluation of the dioxin mass balance over the scrubber resulted in the conclusion that without PAC dosing the combined amounts of dioxins in the outlet flue gas and in the wash water was about twice the amount of dioxins in the inlet flue gas, as a result of the previously described "memory effect". The indicated ratio between outgoing and ingoing dioxin amounts quickly increased to about 10-14 when SA Super was added to the wash water, and gradually decreased to 3-7 after about three months as a result of the reduced "memory effect". The increased outlet of dioxins through the wash water was realized solely by the large amounts of dioxins adsorbed on the PAC. This shows that the PAC removed dioxins actively from the scrubber, therefore, the duration of the "memory effect" can be shortened with ACI in the wash water.
The optimization of Incinerator B resulted in the stack emission values presented in table 2.

Table 2 Stack emissions of dioxins after optimization program (in ng TEQ/Nm^3).

Time passed after optimization	Line 1	Line 2	Line 3	Line 4
3 months	0.08 ± 0.02	0.07 ± 0.01	0.14 ± 0.02	0.13 ± 0.01
4 months	0.05 ± 0.003	0.05 ± 0.003	0.05 ± 0.007	0.10 ± 0.01
5 months	0.05 ± 0.02	0.04 ± 0.005	0.05 ± 0.006	0.07 ± 0.01
6 months	0.05 ± 0.005	0.03 ± 0.005	0.04 ± 0.002	0.06 ± 0.003

Incinerator C: AVIRA Duiven (NL)

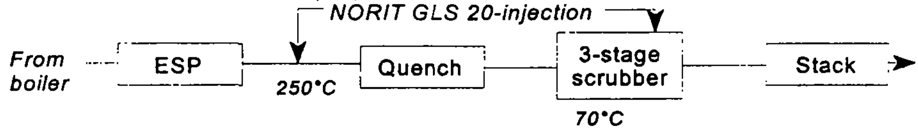

Figure 3 Schematic representation of the flue gas cleaning installation of AVIRA.

The municipal waste incinerator AVIRA consists of three lines producing about 80000 Nm^3/h

flue gas each. The configuration of its flue gas cleaning installation is represented in figure 3. Simultaneous with the start of the ACI in Januari 1995 (initially with NORIT GL 50), an extensive dioxin measurement program was started. The dioxin emission levels of two of the three lines were readily reduced to below the effective emission limit (0.4 ng TEQ/Nm^3 at that time), with a PAC dosing rate of about 150 mg/Nm^3. Due to the absence of a boiler in the remaining line, it was more difficult to reduce the emission of this line more effectively. Optimization of the carbon type used, i.e., switching to NORIT GLS 20 and adding NORIT GLS 20 to the wash water, resulted in the necessary reduction of the dioxin emission in this line also. At present this line has been adjusted to minimize the emission even further, so that all lines now comply with the current dioxin emission limit of 0.1 ng.TEQ/Nm^3. Furthermore, the concentrations of heavy metals in the process water also reduced thanks to ACI.
The flue gas cleaning process according to the design of AVIRA is called the ADRT process (AVIRA Dioxin Reduction Technology) and has been patented recently (4). In the patent the possibility is mentioned to add NORIT GLS 20 to the wash water in case there are problems with a "memory effect". During the first months of operation the "memory effect" also became apparent at AVIRA. This is illustrated in tabel 3, which contains the dioxin stack concentration during the first 18 months of operation.

Table 3 Dioxin emission data of line 1 of AVIRA (inlet approximately 0.8-1.6 ng TEQ/Nm^3).

Date	Dioxin level (ng TEQ/Nm^3)	Date	Dioxin level (ng TEQ/Nm^3)
31/1/95: Start of ACI in flue gas (NORIT GL 50)	0.29	8/9/95: Start additional ACI in wash water (NORIT GLS 20)	0.34
21/3/95	0.27	21/9/95	0.26
14/6/95	0.24	14/3/96	0.05
24/8/95	0.33	27/6/96	0.05

Conclusions

NORIT SA Super and NORIT GLS 20 can be applied effectively in combination with wet scrubber systems to comply with the highest dioxin emission limits. Also the "memory effect" observed in many wet scrubber systems can be treated succesfully with both carbon types.

References

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