PCDD/F Removal from Gases using a Dry Adiox Absorber

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Introduction

A new process for removing PCDD/Fs from gases has been developed[1]. The process is based on a new construction material, in which carbon particles are dispersed in a polymer matrix, such as PP (polypropylene). In this new material, called Adiox(patent pending), the PCDD/Fs are first absorbed in the polymer and then they diffuse to the surface of the carbon particles where they are irreversibly adsorbed. Several types of components, such as tower packings and droplet separators, can be produced from Adiox and employed in gas cleaning systems.

As per April 2005, Adiox tower packings had been installed in wet flue gas cleaning scrubbers at more than 30 full-scale incineration lines with gas flows ranging from 5 000 to 100 000 m^3/h (n., d.g.). The removal efficiency depends on the amount of installed material. In some plants, a limited amount is installed to increase the safety margins or to reduce the memory effect[2]. At Måbjergvaerket in Denmark, wet Adiox scrubbers in combination with one ESP per line act as the main PCDD/F filter since the fall of 2004. The five PCDD/F measurements done until this date show concentrations in the stack far below the emission limit. Such an installation, however, requires more stages than a traditional wet scrubber installation.

If Adiox is employed in a dry absorber instead of a wet scrubber, the removal efficiency per installed amount is higher, since the water film in a wet scrubber poses a mass transfer limitation for the PCDD/Fs. The operational advantages of such a dry absorber have been outlined earlier[3]. A pilot scale dry Adiox absorber has therefore been tested in Swedenat the Renova municipal waste incinerator of Göteborg since July 2004.

Materials and Methods

The absorption of PCDD/Fs in Adiox was initially tested in laboratory experiments[4]. Dry gas containing PCDD/Fs was passed through a fixed bed of Adiox granules at 80 °C. No break-through of the lower chlorinated PCDD/Fs was detected after one month. Upon heating the granules to 120 °C, the desorption was negligible. Granular beds have porosities around 30%. If the gas contains particles, parts of the bed may be clogged, leading to channelling and increased pressure drop. Tower packings, originally designed for the use in wet scrubbers, can be used instead. The porosity is typically 95%, which reduces the risk for clogging.

The dry absorber, using Adiox tower packings, was installed at line 1 of the Renova incinerator in Göteborg. The flue gas treatment consists of an ESP, two wet scrubbers, reheater and a bag house filter as seen in Figure 1. The second scrubber is used for enhanced energy recovery with flue gas condensation by cooling the gas from 60 to 40°C using heat pumps during the cold season. The gas is reheated approximately 20 °C leading to bag house temperatures of 60-80°C.

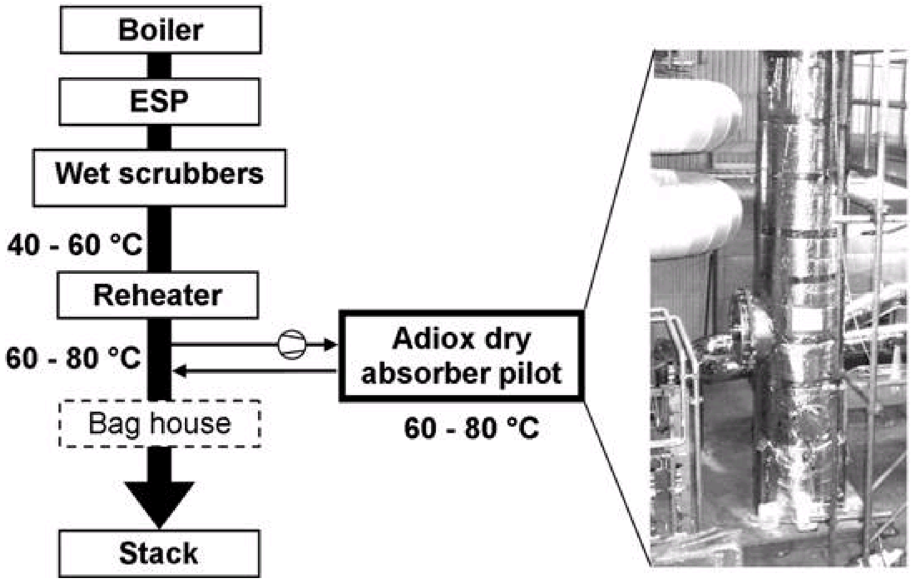

Figure 1. Pilot Adiox absorber at the Renova municipal waste incineration plant in Göteborg, Sweden. The dry Adiox absorber is located downstream of an ESP, wet scrubbers and reheater.

The pilot scrubber operates with a fraction of the total gas flow (approximately 3000 m^3/h) extracted after the reheater. Today, the PCDD/Fs are removed in the bag house filter.

The PCDD/F concentrations upstream and downstream of the dry absorber were measured according to EN1948. The sampling time was 6 h for all measurements except for one 4 h sampling. The filter and probe rinsing liquids were analysed separately for PCDD/Fs. The particle filter was heated to < 10 °C above the flue gas temperature during sampling in order to have similar conditions at the filter and in the gas. The measurement of PCDD/F gas-particle partitioning may be subject to large sampling artefacts[5]. The particle phase PCDD/Fs is overestimated due to additional PCDD/F adsorption at the particles during sampling, whereas PCDD/F desorption from the particles at the filter is negligible at temperatures below 200 °C.[5]

Results and Discussion

The PCDD/F removal efficiencies during the first 9 months of operation are shown in Figure 2. The inlet concentrations ranged from 0.7 to 2.0 ng I-TEQ/m^3 (n, d.g., 11% O_2), and the clean gas concentrations ranged from 0.002 to 0.02 ng I-TEQ/m^3 (n, d.g., 11% O_2).

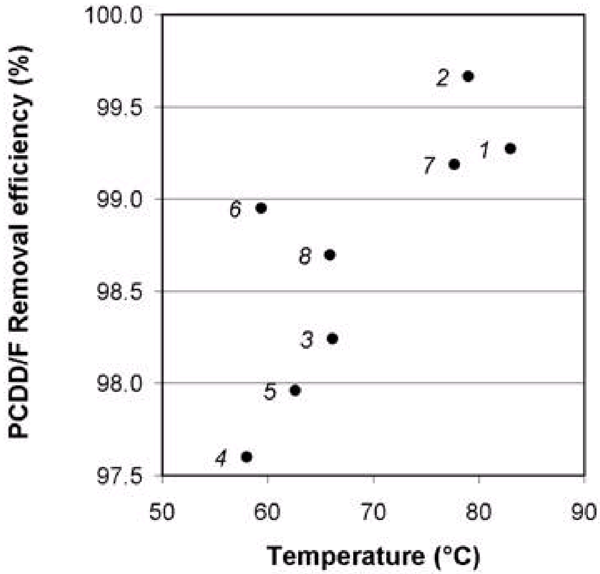

Figure 2. The PCDD/F-removal efficiency of the dry Adiox absorber. The numbers 1-8 refer to the chronological order of the measurements.

This limited number of data points suggests increasing removal efficiency with increasing temperature. The higher diffusivity of PCDD/Fs in plastics at higher temperature is a possible explanation. No trend of decreasing removal efficiency with time could be seen. The actual gas flow ranged from 2900 m^3/h to 3400 m^3/h except for measurement nos. 4 and 6 where the gas velocities were lowered. The highest particle concentration was measured in no. 4 (10 mg/m^3 at 1200 m^3/h), which coincided with the lowest removal efficiency for PCDD/Fs. The removal efficiency was higher in measurement no. 6 (2000 m^3/h) than in nos. 3 and 5 made the same week at comparable gas temperature.

In the inlet, the particle filter accounted for 0.4-3.5 % of the total PCDD/Fs in the sample, while the corresponding values for the clean gas was 4-27%. The PCDD/F concentrations associated with the filter typically decreased by a factor of 5, while the particle removal efficiency only was in the order of 20-50%. These results suggest that the particulate PCDD/F is overestimated in the inlet by the sampling technique due to additional PCDD/F absorption on the particles at the filter, which is in agreement with earlier findings[5].

One important consideration for the pilot test was to assess the amount of fly ash collected on the Adiox surface during operation. No rinsing of the tower packings was therefore made during the test. After 9 months, the Adiox tower packings were covered by a thin, porous layer of particles, which could easily be removed by rinsing with water. No change in pressure drop or decrease in removal efficiency with time could be seen during the period.

The aim of this pilot installation is to demonstrate how the complete PCDD/F removal can be achieved in a single-stage passive, robust piece of equipment downstream of a conventional flue gas cleaning system. The selectivity for PCDD/Fs and high loading capacity of Adiox makes it very suitable for PCDD/F removal[3]. After use, the Adiox material can be incinerated. The PCDD/Fs are then destroyed.

References

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