ADVANTAGE OF GAS SUSPENSION ABSORBER IN DIOXINS REMOVAL

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Abstract

Gas suspension absorber (GSA) has an inherent advantage over the conventional semi-dry systems (employing rotary atomizers) for flue gas treatment in waste incineration. The dense phase of suspended solids in reactor is condusive to condensation of dioxins (PCCD/F) during cooling. Measurements have shown that PCDD/F are partitioned in about 6/1 ratio between solid/gas phases and that 0.1 ng/Nm^3 TE emission limit can be met, even under very unfavorable conditions.

DIOXIN PHASE EQUILIBRIA

The dioxins are formed in waste incineration systems by the de-novo synthesis at temperatures in the range of 200-400°C as postulated by Stieglitz[1], Vogg[2] and other researchers. Once the PCDD/F are formed they partition between the vapor, liquid and solid phases (fly ash) depending on the spatial and temporal temperature profile within the waste incineration plant.

The fugacity calculations by Schramm et al[3], showed that the emissions of dioxins from incineration depends on the partition of these compounds between stack gas (gas phase) and fly ash (solid phase). The calculations showed that the separation of fly ash at low temperature should decrease total emissions up to a factor of hundred. Increased fly ash concentrations would also enforce the separation effect, whereas low particle concentration in the gas phase lead to relatively high amounts of PCDD/F in the gas phase.

Based on a study of Danish Ministry of Environment on dioxins emissions from waste incineration plants Boscak[4] has shown that the exit gas temperature is the major parameter dictating PCDD/F concentration in the stack gases.

Upon sufficient temperature reduction, PCDD/F present in the gas phase willeither condense on fly ash or other solids (heterogeneous condensation) or undergo homogeneous condensation. Since the aerosols formed through homogeneous condensation of PCDD/F would be in the submicron range, they are very difficult to remove from the flue gas. The presence of PCDD/F aerosols in the flue gases and the problems with their collection even in the sampling train have been reported by Fängmark et al[5]. The study has shown that an aerosol filter has to be introduced after the condenser to collect PCDD/F efficiently. On the other hand PCDD/F condensed on the solids is readily collected in the particulate control equipment.

SPRAY DRYER ABSORBER

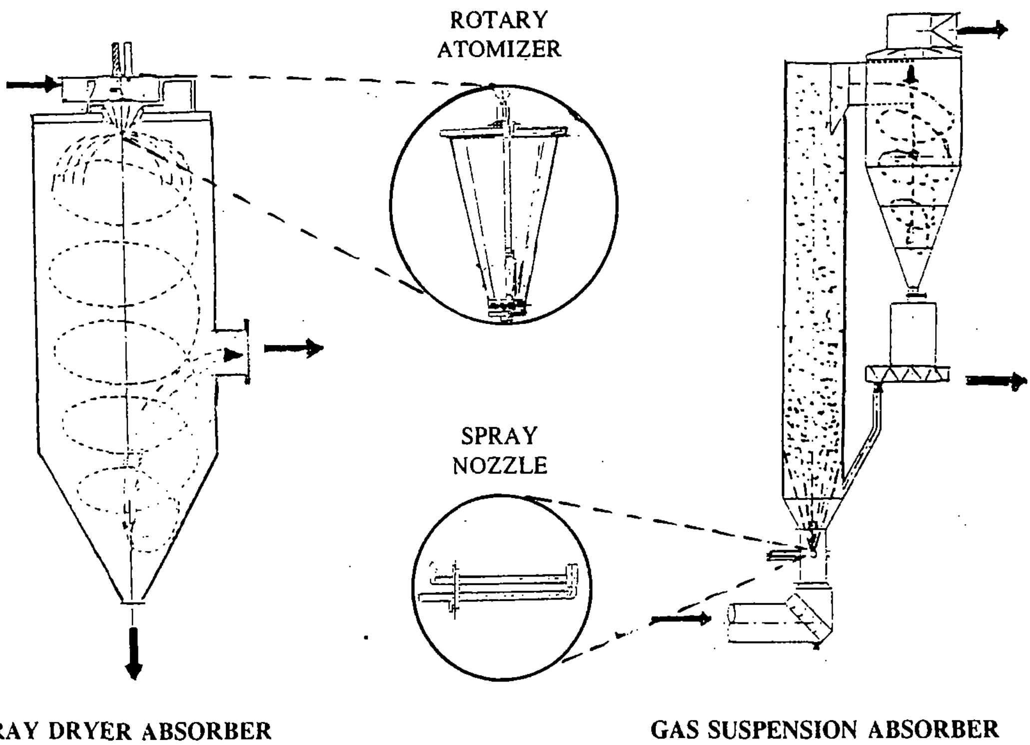
The state-of-the-art technology for flue gas cleaning from waste incinerators is semi-dry system typically consisting of the spray dryer absorber(s) equipped with rotary atomizer or reactor(s) equipped with batteries of high pressure atomizing two fluid nozzles. In either case, the goal of slurry atomization is to produce droplets with a mean size of 50-75 micron diameter. This fine droplets are required for high efficiency because the absorbent is contacted with acid gases only once. To generate these fine droplets the rotary atomizer wheel rotates at about 12,000 rpm. This makes it a high cost, high maintenance technology. The choice of atomizing method will, indirectly, dictate the physical dimension of the spray dryer itself. If rotary wheel atomization is chosen, then the lenght-to-diameter ratio (L/D) of the spray dryer is typically in the range of 0.7 to 0.9, implying a bulky configuration.

GAS SUSPENSION ABSORBER (GSA)

GSA is a novel semi-dry system characterized by the absorbent recirculation through reactor. As in the case of spray dryer absorber, the removal of reaction products and fly ash takes place in either baghouse or electrostatic precipitators.
The flue gas from the boiler is introduced to the bottom of the reactor and is passed through the conical section where the simple two fluid nozzle is located. In a typical application lime slurry is injected upward into the reactor with compressed air to form coarse droplets which wet the sorbent.
The reactor is filled with the suspended sorbent consisting of reaction products, unreacted lime and fly ash with the density as high as 500 - 2000 g/Nm^3. This concentration is 50 to 100 times higher than in the spray dryer absorber and thus provides much larger surface area for acid gas absorption and adsorption of heavy metals and dioxins.
The suspended sorbent travels with gas to an integral separating cyclone from where about 99% of it is recycled to the reactor via the screw conveyor. This means that the sorbent is recycled about 100 times so that unused lime content in the sorbent can continue to react, thereby lowering the overall lime consumption. Due to the recirculation the reaction byproducts have a layered structure and larger particle size than the products from the spray absorber and are easier to handle.

GSA ADVANTAGES

The figures on the next page illustrate two advantages of GSA over spray dryer absorber (adopted from reference 6): compact reactor design due to the higher gas velocity and a simple nozzle compared to the high cost/high maintenance rotary atomizer.



The general advantages of GSA over spray dryer absorbers can be summarized as:
* Low lime consumption
* Few moving parts (no rotary atomizer)
* Great flexibility
* Modest space requirements
* Nozzle change during operation

DIOXIN TESTS AT KARA

One of the larger waste-to-energy plants in Denmark is I/S Kara employing four waste incineration lines with the total capacity of about 20 t/h. The flue gas cleaning is accomplished primarily by three GSA installations followed by either baghouse or electrostatic precipitator.

In order to demonstrate that GSA can meet 0.1ng/Nm^3 TE emission limit a short test program was carried out in November 1992. Unfortunatelly, due to the fixed test schedule PCDD/F emission measurements were carried out under very unfavorable conditions, including unintentional start-up conditions. Previous studies by the Danish Ministry of Environment have shown that PCDD/F emissions during the start-up are exceptionally high. PCDD/F emissions were measured at two incineration lines both employing GSA but one followed by a baghouse while the other used electrostatic precipitator. One variable used in both lines was the addition of active coal as shown in Table 1 which summarizes the tests.

TABLE 1. GSA DIOXINS TESTS

Test number	Configuration	Inlet ng/Nm^3 TE	Outlet ng/Nm^3 TE	Active coal kg/h
1	GSA + baghouse	11.3	0.76	0
2		"	0.57	3
3		"	0.11	10
4	GSA + electrostatic precipitator	38.4	8.8	0
5		"	0.85	10

Due to the limited number of samples which could be taken during tests at Kara only one inlet sample was taken at each line. The high inlet PCDD/F concentrations indicate the upset conditions in particular in the line using electrostatic precipitator. One should note that typical inlet concentrations are in single digits. Another problem with the line consisting of GSA and baghouse was that exit gas temperature was about 142°C instead of the desired 130°C. This happened because of erroneous temperature sensor measurements. Nevertheless, this line showed that 0.1 ng/Nm^3 TE could be achieved when 10 kg/h of active coal were added to the flue gas upstreams from the GSA.

It is important to note that PCDD/F emission concentrations correlate well with the particulate concentration in the exit gas. The lower the particulate concentration the lower the PCDD/F concentration. For example in test number 3 where PCDD/F emission was 0.1 ng/Nm^3 TE the particulate concentration was only 5 mg/Nm^3.

To verify the premise that PCDD/F will condense on the solids in the reactor as temperature drops a sample taken in flue gas after GSA but before baghouse was analysed for PCDD/F content in gas and solid phase. The test showed 0.61 ng/Nm^3 TE in solids and 0.12 ng/Nm^3 TE in gas phase.

This findings confirmed GSA's inherent advantage for PCDD/F control over other semi-dry systems due to the high sorbent density in reactor and low exit gas temperature.

LITERATURE

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