PCDD / PCDF emissions from modern hazardous waste incineration plants

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1. Introduction

Waste incineration plants, both for municipal and for hazardous waste, have increasingly attracted the interest of the public. This refers mainly to the emissions of these plants to air, soil and water. The major pollutant of concern in the opinion of the public are the emissions of PCDD / PCDF. This has led in many countries to the introduction of a PCDD / PCDF emission limit in the fluegas of 0.1 ng TEQ / Nm^3.

To achieve this rather low limit, an improved combustion is essential. By reducing the potential precursors for dioxin-reformation, low dioxin levels can potentially be achieved without the need for additional equipment like active carbon filters.

This paper will describe the development of an improved secondary combustion chamber, its application to a hazardous waste incineration plant and the measurement results regarding combustion efficiency, especially with respect to PCDD / PCDF emissions.

2. Background

Secondary combustion chambers are required by law in hazardous waste incineration plants. They should provide for complete burn-out of the flue gases but are also used for injection of additional quantities of liquid waste.

Traditionally, these chambers have been built as rectangular chambers. This is not the optimum shape with respect to fluid mechanics, giving rise to dead areas and thus leading to poor mixing of the flue gas with the waste. This has caused both operational and emission limit problems, spawning the need for the development of a more efficient secondary combustion chamber.

To better fulfil the three T's of combustion:

- time
- temperature
- turbulence

a round chamber has definite advantages.

3. Development of the Secondary Combustion Chamber with Tangential Injection of Air and Liquid Waste

To enhance the combustion efficiency, we have developed a new secondary combustion chamber, the Vortex-SCC [1]. The principle schematic of this secondary combustion chamber is shown in Fig. 1. Into the round secondary combustion chamber, secondary air and liquid waste are injected tangentially, thereby creating a vortex motion that will lead to thorough mixing of the flue gases with the waste.

The secondary air is injected in stages, thereby giving the impulse for the Vortex motion. Typically, 5 stages of 2 nozzles each are located along the height of the secondary combustion chamber. The lances for liquid waste injection are located between the secondary air levels.

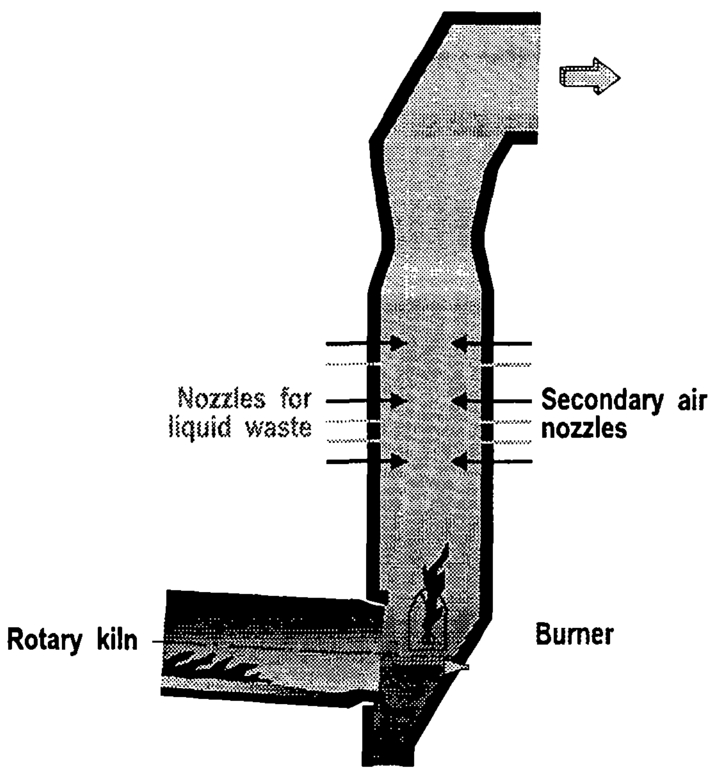
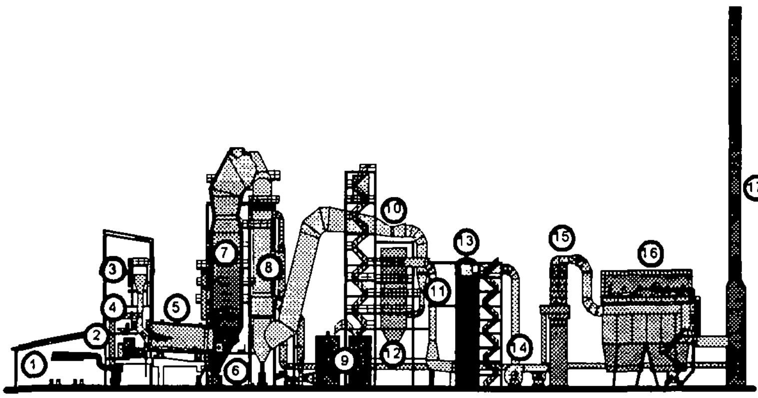


Fig. 1 Secondary Combustion Chamber with Tangential Injection of Air and Liquid Waste

Flow simulations were performed first on a plexiglass model. This way, the concept was proven and valuable information on the distribution of the secondary air over the different levels with respect to optimal performance of the secondary combustion chamber was gained. These simulations gave the input and assurance for the planning and construction of the first new secondary combustion chamber, which was installed at the Cleanaway Hazardous Waste Incineration Plant in Ellesmere Port, UK.

4. The "Cleanaway" plant

An outline of the Cleanaway plant is shown in Fig. 2. This plant has a yearly throughput of around 70'000 tons of hazardous waste and a thermal capacity of 35.2 MW. It is a privately owned merchant incinerator, receiving waste from diverse sources.



1. Drum transport
2. Primary air system
3. Solid waste feed hopper
4. Drum feeding
5. Front wall and rotary kiln
6. Slag discharger
7. Vortex secondary combustion chamber
8. Recuperators
9. NaOH-Tanks
10. Saturate venturi quench
11. Variable throat venturi
12. Scrubber with acid and alkaline stages
13. Scrubber with alkaline stages
14. Induced draught fan
15. Mist eliminator and hot air mixer
16. Fabric filter
17. Stack

Fig. 2 Hazardous Waste Incineration Plant Cleanaway, Ellesmere Port, UK

Heat is only partially recovered by radiation type recuperators located after the secondary combustion chamber. In these recuperators, the fluegas is cooled to about 850°C. The flue gas is then quenched with water to saturation (~ 75°C) in a saturation quench before entering the flue gas cleaning plant, consisting mainly of two scrubbers for acid gas removal and a fabric filter, coated with lime, for dust removal and "polishing" of the flue gas.

5. Results

One clear criterion for the efficiency of the new secondary combustion chamber with respect to the destruction of organic material are the continuously measured low levels of the CO- / C_xH_y-emissions of the plant. For Cleanaway, the daily average values for these emissions are:

CO	< 5 mg/Nm^3
C_xH_y	< 1 mg/Nm^3

For the Cleanaway plant, a PCB DRE (Destruction and Removal Efficiency) of 99.99999% was guaranteed. Results in excess of this guarantee, e.g. 99.999994%, have been achieved consistently.

Measurements of PCDD / PCDF concentrations in the flue gas in the stack have been performed on various occasions over the last three years of operation. The sampling time of typically 4 hours extended in some cases to 8 hours. The sampling method applied is the US EPA Method 23 [2]. Analysis is done by mass spectroscopy. These measurements are summarised in Table 1. They clearly show that right from the start-up of the plant in Sept. 1990, PCDD levels below 0.1 ng TEQ / Nm^3 have been achieved. The congener distribution for the measurement of 29.07.1993 is shown in Table 2.

6. Summary

We have successfully developed and installed a new secondary combustion chamber, the Vortex-SCC. It could be shown that this secondary combustion chamber is clearly superior in terms of its combustion efficiency, proven by the low CO- / C_xH_y-emissions. Moreover, the high DRE for PCB and the low PCDD / PCDF values that were achieved without any additional measures. A second secondary combustion chamber of this new design is successfully operating at the Indaver plant in Belgium since the beginning of 1992. Another one went into operation in May 1993 at Nippon Purle, Japan.

7. References

[1] M. Zweifel: Anlage zur Verbrennung von Sondermüll, European Patent 0 353 491 B1, 29.09.1993

[2] US EPA Proposed Method 23: Determination of Polychlorinated Dibenzo-p-Dioxins, Polychlorinated Dibenzofurans From Stationary Sources, Federal Register Vol.54 No.243, Dec. 20 1989

Table 1: **PCDD / PCDF MEASUREMENTS IN STACK**

Date	PCDD / PCDF Toxicity Equivalent (ng/Nm³)
06.12.90	0.084
29.04.91	0.010
01.05.91	0.013
09.07.91	0.065
10.07.91	0.025
08.10.91	0.055
06.05.92	0.062
07.05.92	0.073
10.11.92	0.021
11.11.92	0.029
26.01.93	0.035
27.01.93	0.037
28.07.93	0.013
29.07.93	0.013
04.12.93	0.052
05.12.93	0.007
07.12.93	0.067

All figures quoted are in ng/Nm^3 as per the EC Draft Directive conditions i.e. temperature 273 K, pressure 101.3 kPa, 11 % oxygen, dry gas. Toxicity equivalents are calculated as per Annex IV of the Directive (I-TEF).

Table 2: CONGENER DISTRIBUTION FOR PCDD / PCDF MEASUREMENTS OF 29.07.1993

Isomer	Concentration (ng/Nm^3)	TEQ (ng/Nm^3)
2378 TCDD	0.00165	0.00165
12378 PeCDD	0.00235	0.00118
123478 HxCDD	0.00212	0.00021
123678 HxCDD	0.00447	0.00045
123789 HxCDD	0.00400	0.00040
1234678 HpCDD	0.02941	0.00029
OCDD	0.16212	0.00016
2378 TCDF	0.02847	0.00285
12378 PeCDF	0.00612	0.00031
23478 PeCDF	0.00753	0.00377
123478 HxCDF	0.00729	0.00073
123678 HxCDF	0.00447	0.00045
234678 HxCDF	< 0.00047	0
123789 HxCDF	0.00424	0.00042
1234678 HpCDF	0.00941	0.00009
1234789 HpCDF	0.00282	0.00003
OCDF	< 0.02635	0
TEQ		0.01299

All figures quoted are in ng/Nm^3 as per the EC Draft Directive conditions i.e. temperature 273 K, pressure 101.3 kPa, 11 % oxygen, dry gas. Toxicity equivalents are calculated as per Annex IV of the Directive (I-TEF).