THE INFLUENCE OF POST COMBUSTION TEMPERATURE PROFILE ON THE FORMATION OF PCDDs AND PCDFs IN A PILOT INCINERATOR .

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INTRODUCTION

In order to minimize the formation of polychlorinated dioxins (PCDDs) and dibenzofurans (PCDFs) in combustion processes it is necessary to know where in the combustion system these compounds are formed. Experience has shown that such studies are difficult to perform in full scale incinerators because of carry over between experiments. Since catalytic reactions are believed to be important it is however advantageous to use techniques where fresh fly ash surfaces could be generated[1]. In a previous study[2] a laboratory scale fluidized bed reactor have been used to study the influence of combustion parameters on the formation of PCDDs and PCDFs. The results from this study shows that the major parameters responsible for the formation of PCDDs and PCDFs are the residence time and temperature profile downstream of the furnace. In the present work the pilot reactor is used to make further studies on the influence of temperature and residence time in the post combustion zone.

MATERIALS AND METHODS

Reactor and fuel

The experiments were performed in a small scale fluidized bed reactor (diameter 0.1m, heigth 1 m) capable of burning around 1 kg of pelletized refuse per hour. The reactor top is connected to a cooling section where the flue gas temperature profile can be varied by cooling, insulating or electric heating. By collecting samples in different sampling ports it is possible to obtain flue gas samples with residence times in the cooling section between 0.8 and 3 s.

To minimize variations in fuel composition a synthetic fuel made from common laboratory chemicals was used in the experiments. The total chlorine concentration in the fuel is 0.7 % by analysis. The reactor and the composition of the fuel is reported elsewhere[3].

Experimental plan

The temperature and the residence time in the post combustion zone was varied according to an experimental plan of full factorial design with three center points. The sampling temperatures chosen were: 260 °C (low), 340 °C (centerpoint) and 510 °C (high). Three sampling ports were available, corresponding to the following residence times: 0.8 s (low), 1.3 s (centerpoint) and 3 (high). The conditions in the combustion zone and freeboard was kept as constant as possible during all experiments, i. e. 7 % O_2 and 875 °C bed temperature. The temperature at the combustor exit was 740 °C and reduced gradually to the desired temperature at the sampling point. In some experiments, when sampling at one of the upstream sampling ports, a second sample was collected simultaneously at the last sampling point (total residence time 3 s). During those experiments the temperature was kept isothermal at 260 or 340 degrees between the two sampling ports. The reactor was vacuum cleaned between the experiments and the sand bed replaced. A blank sample was collected after cleaning with propane as fuel. The experimental plan is described in table 1 below.

Table 1. Experimental plan (- = low, 0 =centerpoint, + =high)

Temperature	Time	Sample at outlet
-	-	yes
+	-	
-	+	
(+	+)	
-	0	yes
+	0	
0	-	yes
0	+	
0	0	yes
0	0	
0	0	

The sampling point (+,+) with high temperature during 3 s was not possible to obtain. Instead two additional samples were collested, namely at 400 °C and 0.8 s residence time and a parallell sample at the last sampling port (3 s), with isothermal conditions in between.

Sampling

In order to exclude the temperature profile in the sampling probe as a contributing factor to the results a cooled probe was used. The cooled probe - polyurethane foam plug sampling technique is described elsewhere[4]. Another advantage with this sampling technique is that fly ash particles are separated from the gas stream and trapped into a

solvent thus minimizing the risk for further reactions to occure. All flue gas samples were collected isokinetically during 20 - 30 minutes.

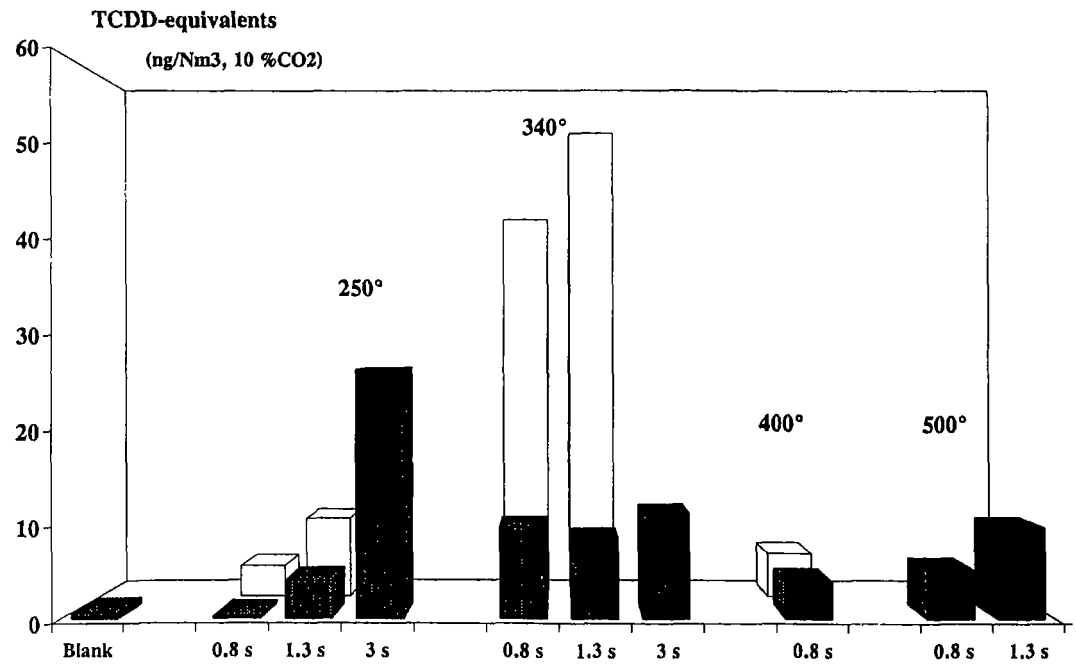
Analysis

Samples were cleaned up according to Marklund[5] and analyzed on HRGC-HRMS (VG 70E).

RESULTS AND DISCUSSION

Figure 1 reports the results expressed as TCDD-equivalents (Nordic) per Nm^3 and 10 % CO_2. The solid bars indicate results obtained when the flue gas is cooled succesively from the exit temperature of the freeboard to the given sampling temperature during 0.8, 1.3 and 3 s residence time. The open bars show the amount found in the second sample collected at the last sampling port (residence time 3 s) which was subjected to isothermal temperature conditions between the two sampling ports.

Figure 1. TCDD-equivalents found at different temperature profiles and residence times in the post combustion section. (solid bars = cooling gradually to the indicated sampling temperature, open bars = when isothermal conditions is added from the given residence time up to a total residence time of 3 s)



The conclusions that could be made from these experiments are:

- The residence time for the flue gas in the cooling section has a marked effect on the formation of PCDDs and PCDFs but at short residence times, 0.8 s and 1.3 s, the production is low at all temperatures studied. The lowest value, in the same size order as the blank sample, was obtained during conditions of rapid quenching (from 740 to 260 °C in 0.8 s).

- If the temperature is kept isothermal at 340 °C for around 2 s the production of PCDDs and PCDFs are the highest.

- When cooling the flue gases from 740 °C (combustion exit temperature) to 340 °C (sampling temperature) in 3 s low amounts of PCDDs and PCDFs are produced compared to when cooling from 740 °C to 260 °C in the same time.

This confirms the rsults obtained by Vogg et al[6] that the net result of formation and destruction of PCDDs and PCDFs are highest in a narrow temperature window around 340 °C .

REFERENCES

1. Altwicker, E. A.. Some laboratory experimental designs for obtaining dynamic property data on dioxins. Sci Tot Environ, 1991, 104, 47 - 72.

2. Fängmark I., Marklund S., Rappe C., Strömberg B., Berge N. Use of a synthetic refuse in a pilot combustion system for optimizing dioxin emission, part II. Chemosphere 1992, 23, 1233 - 1243.

3. Fängmark I., Marklund S., Rappe C., Strömberg B., Berge N. Use of a synthetic refuse in a pilot combustion system for optimizing dioxin emission, part I. Chemosphere 1990, 20, 10-12, 1859-1866.

4. Fängmark I, Wikström L-E, Marklund S, Rappe C. Studies on sampling methods for PCDDs and PCDFs in stack emission. Chemosphere, 1990, 20, 10-12, 1333 - 40

5. Marklund, S. Dioxin emission end environmental imission. Thesis, University of Umeå, 1990.

6. Vogg, H., Metzger, M., Stieglitz. L. Recent findings on the formation and decomposition of PCDD/PCDF in municipal solid waste incineration. Waste Management and Research, 1987, 5, 285-294.