

FORMATION AND SOURCES I -POSTER

PILOT INCINERATION PLANT „VERONA“ FOR STUDIES ON THE FORMATION AND DECOMPOSITION OF POLYHALOGENATED PXDD/F AND OTHER ORGANOHALOGEN COMPOUNDS

Doris Schöler, Johannes Jäger

TU Darmstadt, Institut WAR, Petersenstr. 13, 64287 Darmstadt, Germany, e-mail j.jaeger@iwar.tu-darmstadt.de

Introduction

The pilot incineration plant VERONA is designed to investigate the formation and decomposition of PXDD/F and related organohalogen compounds during combustion processes. The combustion chamber allows the incineration of solid fuel in batch operation and the continuous incineration of gaseous fuels with a thermal power between 30 and 50 kW. Further main components are the post combustion chamber, the heat exchangers and the flue gas cleaning devices. The combustion chamber has a volume of 60 l. This size allows to carry out a series of measurement runs with comparatively short preparation times when composing defined model fuels and changing crucial parameters such as fuel composition, air input, residence times and temperatures. In order to analyse the flue gas simultaneously in all incineration stages the plant is equipped with numerous sample points.

Methods and Materials

The flow sheet of the plant VERONA is illustrated in figure 1. It shows the cylindrical combustion chamber with a 75 mm ceramic insulation layer and an outward cover of stainless steel. The primary air passes from the grate in the bottom to the top of the fire bed. The ignition is initiated by the electrical heating which is installed in the top of the chamber and serves during the whole incineration process as heat radiation source above the fire bed. If required the surface and the volume of the fire room can be reduced by the insertion of further ceramic elements. For the continuous operation with gaseous fuels a burner is installed in the lower part of the chamber above the grate. After the combustion chamber further preheated air is injected in the duct connecting the combustion and the post combustion chamber. This duct section is additionally heated and temperatures according to the experimental requirements can be adjusted. Subsequently, the flue gas is injected into the post combustion chamber and mixed with preheated secondary air under turbulent conditions. The post combustion chamber consists like the combustion chamber of an inner ceramic insulation and an outward coat of stainless steel. Inner heating rods compensate the heating losses and can be used for an additional heating up to temperatures of 1.400 °C. The post combustion chamber is designed for a residence time of the flue gas of 2 s above 850°C. After the post combustion chamber five separate heat exchangers are installed. Between these heat exchangers further insulated ducts can be inserted in order to rise the residence time on the distinct temperature levels. Furthermore the temperature profile during the cooling process can be varied by removable insulation layers and flexible water cooling systems in the heat exchanger elements. This range of possible changes of the residence time during the cooling process was designed due to its significant influence on the formation of PXDD/F¹. The

FORMATION AND SOURCES I -POSTER

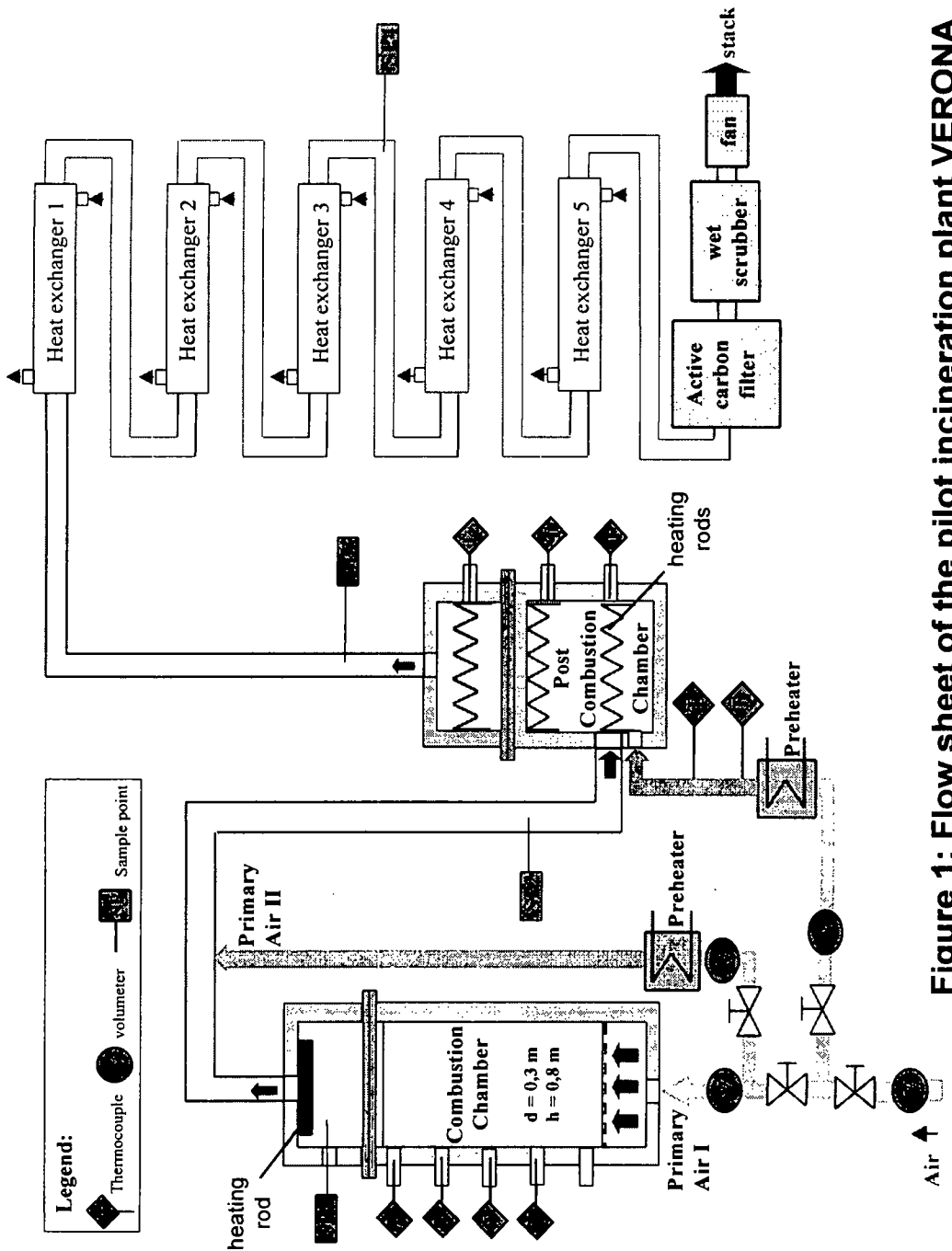


Figure 1: Flow sheet of the pilot incineration plant VERONA

FORMATION AND SOURCES I –POSTER

following flue gas cleaning facility consists of an active carbon filter and a wet scrubber. At the end of the plant a suction fan is installed in order to operate the whole system under weak vacuum conditions.

Furthermore the facility is equipped with an online data monitoring system collecting about 40 parameters such as temperatures, flow rates, pressure, CO-content and O₂-content. For the control of the temperatures in the fire room, the post combustion chamber and the air preheaters PID-control devices are installed. In order to take samples in all stages of the incineration processes numerous sample points are provided in the combustion chamber, the post combustion chamber, the heat exchanger and the flue gas cleaning devices.

The first measurement campaign investigates the formation and decomposition of polyhalogenated dioxins, furans, phenols and benzenes arising from the incineration of solid fuels with focus on the role of bromine. Additionally, the evaluation aims at the identification of indicator compounds in early incineration stages which correlate to dioxins and related compounds which are formed before and after the cooling process. Untreated wood is chosen as basic fuel and doped with defined compounds which serve as halogen source or catalyst. As organic chlorine and bromine source trichloroethane, 2-bromobutane and tribromophenol are injected gaseously into the primary air by a HPLC-pump with a subsequent heated capillary. As catalyst a copper(II)-compound² – copper(II)acetate – was chosen and added to the wood bed. Besides the chlorine and bromine input additional parameters such as a primary and secondary air inlet, temperature in the combustion chamber, temperature between combustion and post combustion chamber, residence time in the heat exchanger elements, water content of the fuel and fuel size are varied.

Figure 1 shows the four sample points SP1 – SP4 where samples are currently taken. As adsorbents in the different sample devices for the sample points SP1 – SP3 (SP1 above the fire bed, SP2 in the duct between combustion and post combustion chamber, SP3 after the post combustion chamber) are used soda solution, silica gel and active carbon for the analysis of HCl, HBr, phenol, benzene, toluene, halogenated benzenes and phenols and numerous other organohalogen compounds. These samples are taken with water cooled sampling probes made of precision steel pipe at flow rates of 0,5 – 2 l/min and temperatures of 800 – 900 °C. An isokinetic gas sampling would require a very small diameter of the sampling probe with the risk of following choking. Therefore high temperature-resistant quartz glass filters were installed directly at the flue gas channel and only the gas phase is considered. At sample point SP4 which is situated after the third heat exchanger samples are taken on XAD-resin at gas temperatures of 180°C for the analysis of PXDD/F, halogenated phenols and halogenated benzenes.

Results and Discussion

When using wood as basic fuel the reaction front passes steadily from top to bottom as observed in similar plants^{3,4,5}. Depending on the operation conditions we receive a stable interval of 15 to 30 minutes with rather constant performance concerning the combustion velocity, the temperatures and the CO-content. During this stable interval samples are taken. In order to reduce the memory effect of previous runs the plant is fed with propane gas without any addition of halogens before every new measurement run.

FORMATION AND SOURCES I -POSTER

The first laboratory results indicate that the PCDD/F pattern of the runs with chlorine addition is similar to the pattern of large scale MSWIs⁶. Hereby the residence time in the heat exchanger at temperatures between 200 – 650°C is about 3 s, which corresponds with the residence times in a large scale MSWI used for comparative studies⁷. Furthermore the first runs show correlations between the I-TEQ and the concentration of penta- and hexachlorbenzene in the raw gas as it was reported from large scale MSWIs.^{8,9}

A correlation between CO-content and emissions of PCDD/F could not be verified at the VERONA in accordance to former reports from real scale incineration plants¹⁰. A run with a low CO-content of about 10 ppm but unfavorable conditions such as a too low primary air input and a temperature decrease before the post combustion chamber resulted in high emissions of PCDD/F in the raw gas. This was also true for a run with untreated wood without further chlorine addition where on unfavorable operation conditions PCDD/F-emissions up to 2 ng I-TEQ/m³ arised though the CO-content was not higher than 20 ppm.

Acknowledgements

We would like to thank the workshop and the laboratory of the Institute WAR for the installation of the plant and their assistance. The measurement programm is co-financed by the Deutsche Forschungsgemeinschaft.

References

1. Hiraoka, M.; Sakai, S.; Sakagawa, T.; Hata, Y. (1997) Organhalogen Compounds, Vol. 31
2. Ballschmitter, K.; Bacher, R. (1996), Dioxine – Chemie, Analytik, Vorkommen, Umweltverhalten und Toxikologie der halogenierten Dibenzop-dioxine und Dibenzofurane, VCH-Verlag Weinheim, ISBN 3-527-28768-X
3. Gort, R. (1968), On the propagation of a reaction front in a packed bed, Dissertation, University Twente, ISBN 90-9008751-6
4. Richers, U.; Walter, R.; Meichelböck, H. (1998) in: Experimente und Modellierung zur heterogenen und homogenen Verbrennung, Wissenschaftliche Berichte Forschungszentrum Karlsruhe FZKA 6084
5. Lohf, A. (1999), Modellierung der chemisch-physikalischen Vorgänge im Müllbett von Verbrennungsanlagen, Dissertation, TU Darmstadt
6. Rappe, C. (1994) Fresenius J. Anal. Chem., 348, 63-75
7. Unpublished data of a German MSWI (1990)
8. Kaune, A.; Schramm, K.; Henkelmann, B.; Boesel, U. (1996) Organohalogen Compounds, 27, 159-162
9. Kaune, A.; Schramm, K.; Zimmermann, R.; Kettrup, A.; Jaeger, K.; Rükkel, L.; Frank, F. (1998) Environmental Engineering Sciences Vol 15, No. 1
10. Hunsinger, H., Kreis, S.; Seifert, H. (1997) Chemosphere Vol.34, Nos 5-7