Dioxin emission reduction of a municipal waste incinerator by injection of activated carbon – the abatement of memory effects

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Introduction

Since 1 January 1997 the emission limit value of dioxins in the flue gases of municipal waste incinerators in Flanders, Belgium, has been reduced to 0.1 ng TEQ/Nm³. In order to fulfil this requirement, most installations had to take specific measures, generally including the dosed injection of activated carbon.

On the municipal waste incinerator of IVAGO in Gent the existing wet flue gas cleaning was extended with an activated carbon injection unit.

This paper describes the dioxin reduction in the emissions of the installation and the observed memory effects.

Construction of the plant

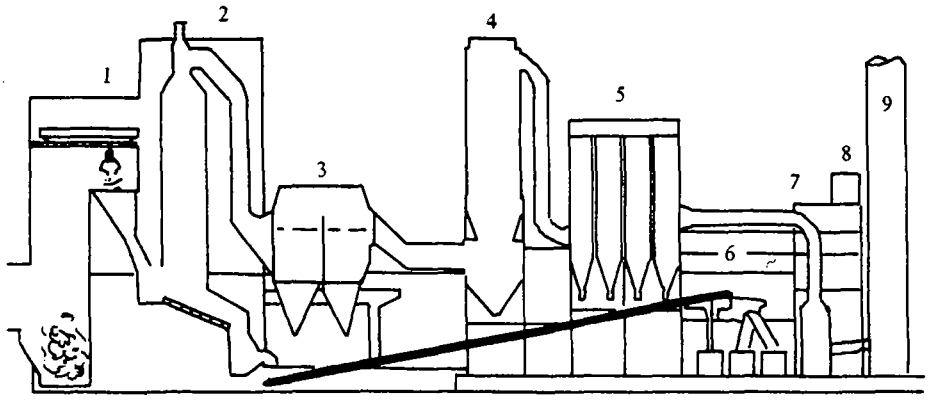
The MWI IVAGO was built in 1979 with a nominal capacity of 2 x 5,5 ton/h and a two-field electrostatic precipitator. In 1996 the installation has been rebuilt according to the scheme in figure 1. On both lines, a two-field electrostatic precipitator removes most of the dust before the flue gases enter a semi-dry gas cleaning system where a lime-suspension is atomised in the flue gas. At the top of the reactor activated carbon is dosed at an adjustable rate into the waste gas to reduce PCDD and PCDF. The remaining dust is then removed in PTFE bag filters. The flue gas is further cleaned by a wet scrubber and demister before entering the stack. The wet scrubber is filled with 70 m³ of polypropylene ETAPAC 210 packing (7000 pieces/m³, 220 m²/m³).

Historical overview of emissions and dioxin emission reduction plan

The new plant was put into service in August 1996 on line 1, followed by line 2 in October. NORIT GL 50, a steam activated carbon was added at a rate of 4 kg/h/line, corresponding with a dose of 60 mg/Nm³. This carbon is especially suitable for the removal of dioxins and its fine particle size contributes to its good adsorption kinetics.

The measurements of the dioxin-content in the flue gases in March 1997 however resulted in 6.2 ng TEQ/Nm³ for line 1 and 21.9 ng TEQ/Nm³ for line 2. For that reason a measurement program was started to investigate the influence of the activated carbon dose on the dioxin emission and eventual memory effects as a result of the start op phase when the plant was running without carbon injection.

Figure 1: Scheme of the waste incineration plant of IVAGO



1: Refuse storage
2: Furnace building
3: Electrostatic precipitators
4: Semi-dry gas cleaning system
5: Bag filters
6: Ash treating building
7: wet scrubber
8: Measuring instruments
9: Stack

New measurements were performed on line 1 on 24 and 25 April with simultaneous samplings after the furnace, after the electrostatic precipitator, after the bag filter and in the stack. The results are summarised in table 1. On both days the dioxin concentration at the different locations decreased in down-stream direction to a level of 0.03 ng TEQ/Nm³ at the exit of the bag filter. But in the stack an increase to more than 1 ng TEQ/Nm³ occurred. Stack measurements on line 2 on 16 May showed a 28-fold excess of the limit value. At first the activated coal injection rate in both lines was doubled on 21 May from 4 kg/h/line to 8 kg/h/line. Nevertheless, stack measurements on line 2 on 27 May still resulted in dioxin concentrations of 2.5 ng TEQ/Nm³. This effect was be explained by memory effects in the wet gas scrubber.

An action plan to reduce dioxin emissions as in table 2 was made. The most significant adaptations were the injection of activated carbon in the wet scrubber and the replacement of the scrubber packing. The results of the measuring program are summarised in the bottom half of table 1. Dioxin concentrations after the bag filters reached a level of 0.035 up to 0.064 ng TEQ/Nm³. The emission limit of 0.1 ng TEQ/Nm³ at this point is respected. The results on line 1 on 05-08-1997 however confirmed the suspicion of memory effects: the dioxin concentration increased between the bag filter and the demister, presumably due to the presence of dioxin on the packing and in the washing water. The decrease in the stack could be explained by elimination of dioxin containing water droplets in the demister. This was not confirmed by the results on line 2 on 28-08-1997; the dioxin content halved between the bag filter and the demister, followed by an increase by a factor 8 in the stack. The PCDD/F profiles on line 2 on 15-09-1997, after ending AC injection in the wet scrubber and halving the AC injection rate in the flue gas from 8 to 4 kg/line/day, however were comparable with those from 05-08-1997 on line 1.

Table 1: Dioxin concentrations in the waste gases

Date	Measuring location	Dioxin conc. ng TEQ/Nm³	Date	Measuring location	Dioxin conc. ng TEQ/Nm³
Line 1			Line 2		
24-04-1997	after furnace	20.5	25-04-1997	after furnace	10.6
24-04-1997	after ESP	5.59	25-04-1997	after ESP	9.39
24-04-1997	after bag filter	0.03	25-04-1997	after bag filter	0.02
24-04-1997	in stack	1.62	25-04-1997	in stack	1.18
			16-05-1997	in stack	2.77
			27-05-1997	in stack	2.52
05-08-1997	after bag filter	0.035	28-08-1997	after bag filter	0.04
05-08-1997	before demister	0.114	28-08-1997	before demister	0.018
05-08-1997	in stack	0.04	28-08-1997	in stack	0.14
15-09-1997	after bag filter	0.048	15-09-1997	after bag filter	0.064
15-09-1997	in stack	0.17	15-09-1997	before demister	0.10
			15-09-1997	in stack	0.069

Table 2: Dioxin emission reduction plan

Date	Actions on line 1	Date	Actions on line 2
15-07-1997	injection of 12.5 kg/day of activated carbon in the wet scrubber	15-07-1997	injection of 12.5 kg/day of activated carbon in the wet scrubber
31-07-1997	replacement of the packing in the wet scrubber	28-08-1997	Dioxin measurement
05-08-1997	Dioxin measurement	11-09-1997	replacement of the packing in the wet scrubber
29-08-1997	injection of 4 kg/h/line AC in the flue gas + end of AC-injection in the wet scrubber	29-08-1997	injection of 4 kg/h/line AC in the flue gas + end of AC-injection in the wet scrubber
15-09-1997	Dioxin measurement	15-09-1997	Dioxin measurement

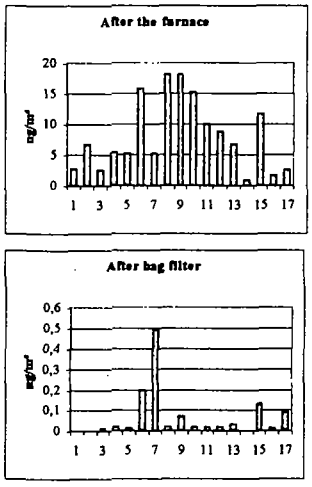
Figure 2 gives an overview of the different congeners, appearing in the flue gas at the various sampling locations of line 1 on 24-04-1997. A comparable pattern was recognisable on all other days.

This figure illustrates an absolute decrease of all compounds after the electrostatic precipitator except the hepta- and octachlorinated that increase considerably. After removal of dust and activated carbon by the bag filter the pattern remains the same but the concentrations of all congeners drop beneath 0.5 ng/m³. In the stack, a remarkable total increase is noticed as well as a reappearance of all congeners. The same patterns were observed the next day.

During the plant adaptations, started in July, simultaneously taken samples after the bag filter, before the demister and in the stack on 05-08 and 15-09, demonstrate increased concentrations of all tetra- through octachlorinated dioxins and furans behind the wet scrubber. Possibilities to

remove them are injection of activated carbon in the wet scrubber and changing the packing materials as illustrated by the evolution of the dioxin contents in time.

Figure 2: PCDD/PCDF-profiles in the sampling locations on line 1 on 24-04-1997



1: 2,3,7,8-TCDD
2: 1,2,3,7,8-PeCDD
3: 1,2,3,4,7,8-HxCDD
4: 1,2,3,6,7,8-HxCDD
5: 1,2,3,7,8,9-HxCDD
6: 1,2,3,4,6,7,8-HpCDD
7: OCDD
8: 2,3,7,8-TCDF
9: 1,2,3,7,8-PeCDF
10: 2,3,4,7,8-PeCDF
11: 1,2,3,4,7,8-HxCDF
12: 1,2,3,6,7,8-HxCDF
13: 2,3,4,6,7,8-HxCDF
14: 1,2,3,7,8,9-HxCDF
15: 1,2,3,4,6,7,8-HpCDF
16: 1,2,3,4,7,8,9-HpCDF
17: OCDF

The profiles demonstrate that memory effects are stronger for the lower chlorinated congeners and these appear in higher concentrations from the wet scrubber than hepta- and octa-chlorinated PCDDs and PCDFs (fig. 3a). After injection of activated carbon in the wet scrubber especially the memory effects from tetra- and penta-CDFs are eliminated (fig. 3b).

Figure 3a: $C_{stack}/C_{after\ bag\ filter}$ on 25-04-1997

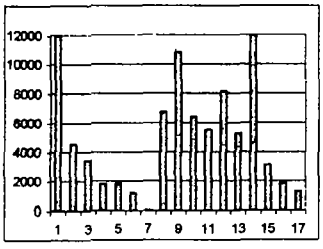
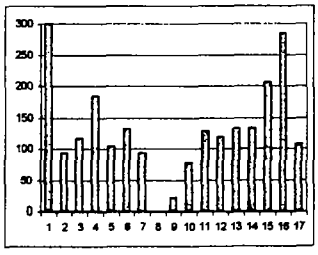


Figure 3b: $C_{stack}/C_{after\ bag\ filter}$ on 15-09-1997



Conclusion

Memory effects from a wet gas scrubber as final cleaning step can give problems to comply with the 0.1 ng TEQ/Nm³dr emission limit. Drastic measures such as replacement of packing material and injection of AC in the scrubber are required.

Acknowledgement

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