Air Pollutant Emissions and their Control – with the focus on waste incineration facilities –

This comprehensive text and practical handbook thoroughly presents the control of air pollutant emissions from combustion processes focusing on waste incinerators. Special characteristics are emphasised and the differences to emission control from combustion processes with other fuels are explained.

The author illustrates the origin and effects of air pollutants from incineration processes, the mechanics of their appearance in the incineration process, primary and secondary measures for their reduction, processes of measuring the emissions as well as the methods of disposing the residues. In particular, the pros and cons of procedual steps and their appropriate combination under various conditions are emphasised.

Moreover, the book contains information and analyses of the emissions situation, the consumption of operating materials and of backlog quantities as well as of the cost structure of waste incinerators with regard to their applied control system. Furthermore, the author explicates the contemporary legal, scientific and technological developments and their influence on air pollutant emission control. An evaluation of the status quo of air pollutant control at waste incinerators in Germany, practical examples about possible combinations and typical performance data complete the content.

Accordingly, this book is a guideline for planing a reasonable overall concept of an air pollutant control that takes the location and the segregation tasks into consideration. This book is addressed to students, decision makers, planners and the operating practitioners if for example the construction of a new system or the implementation of improvement measures have to be conducted.

available in German and English!
In Belgium the municipalities are responsible for the household waste. Before 1970 each municipality in Belgium had a dumping place. All the waste from households and industries was dumped there, giving lots of environmental pollution and annoyance. Especially in the densely populated parts of the country it became practically impossible to find locations for such new dumping places, because they were no more socially accepted. Around 1970 municipalities started to cooperate in intermunicipalities to find a solution for their waste problem.

IVOO (Intermunicipal Association for waste management for Ostend and Ommeland) is erected in 1974 as the intermunicipal organisation for waste management for the town of Ostend and the following five municipalities around: Bredene, Gistel, Middelkerke and Oudenburg: in total more as 144,000 inhabitants. Situated in the middle of the Belgian coast it attracts a lot of tourists.

Firstly, an incinerator was built. From 1990 selective collection of waste was organised with containerparks and door to door collection of packaging waste. In 1998 a facility for the composting of garden waste was built. Nowadays, about 70 % of the municipal solid waste is selectively collected and recycled, only 30 % is treated in the waste-to-energy (W2E) plant.
By order of the six communities the IVOO carries out the directives of Flemish management for waste and materials. Its main activities are:

- The organisation of kerbside collection of municipal waste,
- the communication and the sensitisation on waste matters,
- the exploitation of a green compost centre, and
- the exploitation of an incineration plant for residual waste.

**Mission**

A sustainable management for waste products and materials – circular economy – is the main objective of the organisation. Together with the six communities, it stands for a sustainable waste management: waste prevention, waste recycling and valorisation of raw materials and production of electricity and heat throughout incineration of residual waste.

![Figure 1: Ostend Waste-to-Energy facility](image)


When the installation was concepted and built, waste management was the competency of the federal ministry of public health. With subsidies of the ministry an installation was built following their policy, it means little attention for environmental care: the air pollution control was restricted to an ESP for dust removal.

Thanks to the cooperation with WVEM, the former local intermunicipality for electricity distribution, there was invested in steam boilers and a turbogenerator.
The installation included:

- 2 furnaces with air cooled grate; supplied by Seghers Engineering (now Keppelseghers); the capacity is nowadays $2 \times 4.5$ ton/h or 62 to 65 kton/yr; in the 1980’s it was 25% higher due to a lower NCV of the household waste before selective collection of recyclables;
- 2 Boilers 35 bar 360 °C 14.5 ton/h; supplied by Denayer (now CMI);
- 2 ESP, supplied by Fläkt (now GE);
- 1 stack with a height of 60 meters. Flow rate of the flue gases: $2 \times 30,000 = 60,000$ Nm³/h;
- 1 Turbine + gear + generator, supplied by Acec (now GE). Capacity = 5.5 MWₑ. Yield is nowadays 500 kWh/ton.

Figure 2: Process flow of the waste incineration plant IVOO in 1981

Figure 3: Process flow of the water-steam cycle
2. Status 1991

Since the second state reform of Belgium in 1980 environment is a competency of the regions. Already in 1981 the Flemish authority decided to equip (and support) the Flemish incinerators with a more performant APC.

With subsidies of Flanders a wet scrubber, common for the two lines, is added. It was supplied by Toussaint-Nyssenne (now Munters) and installed by Seghers Engineering.

![Process flow of the waste incineration plant IVOO in 1991](image)


In 1995 the Flemish authority imposes more stringent operating conditions, under which the removal of dioxins out the flue gases. Per line a semi-wet scrubber with injection of lime and lignite coke is installed.

![Process flow of the waste incineration plant IVOO in 1998](image)
4. Status 2004 – EU demands removal of $\text{NO}_x$


The semiwet scrubbers are converted into dry scrubbers with injection of Sodium bicarbonate (reactor becomes evaporation cooler); and the wet scrubber is replaced by a tail-end SCR denox.

The new layout enables to keep a high level of energy efficiency and is only possible with the current flue gas treatment configuration.

![Process flow of the waste incineration plant IVOO in 2004](image)

5. Other adjustments – continuous improvement

In 1997 burners are installed for the reduction of the emissions during start-up and stop. In the same year analysers for continuous control of emissions are installed and a long-term sampling unit for measuring dioxins and furans.

In 1998 the concept of superheaters was changed. In place of horizontal superheaters, vertical ones, with a prolonged lifetime, were installed.

Since 2001 the management system is certified for Quality ISO 9001 and Environmental care ISO 14001.

In 2003 the installation for the production of demineralised water was replaced for Reverse Osmosis (RO) followed with continuous electro-deionisation (CEDI).
Since 2004 the boilers are cleaned every two weeks with the detonative cleaning system Detoclean.

In 2008 an additional catalyst is installed in the denox. The operating temperature is decreased (225 => 185 °C); in normal working conditions the burners are no more working, which results in an important saving on gas consumption. For more information about the low temperature Shell Denox System for removal of NOx and dioxins from waste incineration [2].

Between 2010 and 2018 the membrane walls of the first pass are renewed, cladded with Inconel.

In 2011 the High-Level Control by FuzzEvent is installed for increase of the furnace capacity and reduction of CO-emission [3].

Since 2014 Ready-to-use sodium based sorbent replaces the classical bicar [1].


Continuously the measuring and control equipment (speed control turbine, excitation generator, controller of ESP, plc’s, scada etc.) is replaced by recent versions.

6. Status 2019 – coupling to the district heating

In September 2017 an agreement was made with BeauVent – a private operator of district heating in Ostend – for delivery of heat to the future district heating system, which meant the start of the project.

BeauVent has the aim to develop a district heating system with about 15 km of length in Ostend for delivery of mainly rest heat from waste incineration to residential and industrial consumers of heat in the city.
IVOO is now installing an heat exchanger of 1.5 MW in the stack, for the delivery of 8,000 MWh per year. Further an heat exchanger of 6 MW (expandable with 5 MW and 4 MW) on superheated steam is installed, for the delivery of 2,000 MWh per year during the peaks.

7. Conclusions

First the concern about the public health led to the construction of a waste incineration plant. Later the environmental concern led to higher environmental requirements. Nowadays the energy efficiency becomes more and more important. Since the construction of the waste incinerator from 1979 to 1981 the environmental requirements have several times been strengthened. By making the right investments IVOO managed to keep the installation up-to-date, compliant to all requirements and still profitable.

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Table 1: Evolution of the emission limit values for the flue gases and average daily emission

8. References


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The aim of this study is to demonstrate such discrepancies or dependencies between attainable emission reductions and the emissions-generating energy input necessarily incurred by flue gas treatment technologies in attaining those reductions.

The study initially focuses on current investigations and assessments related to this issue, as well as on the legal emission requirements. Due to the wide range of components involved in flue gas treatment systems and their consequent numerous combination possibilities, six different system Variants are presented and compared. It is notable in the context of the present study that both single and two-stage or multi-stage systems are considered in the set of Variants, which differ not only in their structure and additive use but also in their separation capacity. These six basic Variants reflect the systems frequently employed in practice and represent non-congruent procedural steps with their respective target emission levels. Based on the fact that each of these Variants is already in operation in thermal waste incineration plants, the assessment draws on many years of existing operative experience.

The individual energy demands for the Variants described are determined on the basis of mass, material and energy balances.

Evaluation criteria for energy demand at the different emission reduction ratios are educed from the formulation of emissions-related energy indicators. This establishes a set of tools with which to assess emissions-generating energy demand in the context of emission reduction ratios.