Customized Exhaust Gas Treatment for MBT

Ralf Bisdorf, Thomas Pfliegensdörfer

Tholander Ablufttechnik GmbH, Viernheim

Maßgeschneidertes Abluftmanagement für MBAs

Abstract

Although the strong legislation 30. BImSchV imitating emissions created by MBT since 2001 effecting high costs, the MBT technology is still an attractive solution to minimize the organic content in waste. By combination of several Air Pollution Control technologies the limitations regarding output of N_2O, Odour and Total Organic Carbon in relation to the waste input could be achieved. Invest and running-on costs for the air treatment are rather high. To minimize these costs, an optimal air handling and collection system had been developed. Selective collection of high and low contaminated air and its separate treatment as well as by-pass ducting between these two systems form a major item of this philosophy. Hereby, not only the requirements of the TA-Luft and 30. BImSchV are achieved but also a high degree of flexibility and redundancy.

Thermal oxidizing is actually the state of the art technology to achieve the low TOC clean gas values. Unfortunately the CO_2 emission, by using primary energy, is enlarged drastically.

Keywords

Air management, biofiltration, ammonia scrubber, thermal oxidizing, dust filter, odour, total organic carbon, emission, air pollution control

1 Introduction

On behalf of the limited waste management company Abfallwirtschaftsgemeinschaft Rendsburg-Eckernförde mbH (AWR), since June 2005 the limited company and MBT plant MBT-plant Neumünster has been treating the waste of ca. 700,000 residents of the land Schleswig-Holstein: wastes of the districts of Rendsburg-Eckernförde, Neumünster and Plön and, furthermore, in the scope of contractual agreements the waste of the town of Flensburg and of the district of Nordfriesland. The MBT-plant Neumünster is authorised to process 200,000 Mg/a of domestic refuse, bulky (household) waste and commercial waste similar to domestic refuse plus additionally 160,000 Mg/a of high calorific fractions. After the treatment, these fractions proceed to thermal processing of the municipal utility company Stadtwerke Neumünster.

1.1 Authorisation notification

Due to the fact that the plant is operated in two shifts and does not operate on Sundays and holidays, there is a daytime and a night-time (rest day) operation. For the daytime operation an exhaust gas volume flow rate of max. 104,000 m^3/h and for the night-time operation of 68,000 m^3/h was approved. Since the mass-related limit values of the 30th BImSchV (German Federal Immission Control Ordinance) already imply a tightening in comparison to the requirements of the TA-Luft (technical instructions on air quality control), the emission limit values of the MBT-plant Neumünster should be even lower than those limit values. (cf. Tab. 1)

Table 1 Emission limit values of the MBT-plant Neumünster

Measurement parameters	**Meas. interval**	**Limit values 30th BImSchV**	**Target values differing thereof of the MBT Neumünster**
Total dust	DMV	< 10mg/Nm3	< 7 mg/Nm3
	HMV	< 30 mg/Nm3	< 15 mg/Nm3
Total carbon	DMV	< 20 mg/Nm3	< 15 mg/Nm3
	HMV	< 40 mg/Nm3	< 40 mg/Nm3
	MR	< 55 g/Mg	< 55 g/Mg
Odorous substances	Sample	< 500 GE/m3	< 500 GE/m3
Nitrous oxide (N_2O)	MR	< 100 g/MG	< 100 g/MG
Sum Furan/Dioxin	Sample	< 0.1 ng/Nm3	< 0.1 ng/Nm3

DMV = daily mean value
HMV = half-hourly mean value
MR = mass ratio, referred to 1 Mg Input
Sample = measurement of each sample

The reduced target values of the MBT-plant Neumünster, indicated in half-hourly and daily mean values (HMV, DMV), already require particular adjustment of the exhaust gas treatment. The compliance with the mass-related limit values for Total Organic Carbon and laughing gas (nitrous oxide) pursuant to the 30th BImSchV is an additional issue.

Due to the legal guidelines with regard to the emission mass flow as well as to the exhaust gas quality to be expected, this leads to an extremely limited total exhaust gas volume. In order to not exceed these, considerable restrictions regarding building size and air change rates had to be put up with. Inevitably, this leads to higher impact on the indoor air quality and to the configuration of facilities in cramped surroundings.

In planning, a process-optimized and easy to maintain machine technology had to be sacrificed for the sake of the requirements concerning exhaust gas management.

2 Structure of the MBT-plant Neumünster

2.1 Components and processing steps

In terms of processing and structure, the mechanical-biological waste treatment plant of Neumünster is divided into various sections:

The mechanical treatment in the reception hall contributes to the sorting of foreign materials, iron, usable bulky waste and materials with a high calorific value. Here, the remaining materials are further shredded and prepared for the biological treatment.

The intensive composting is carried out in two parallel arranged lines of composting modules that are respectively arranged in an individual composting hall. The composting modules of the company Biodegma are covered with membranes and force-aerated. The composting exhaust gas is gathered in modules and conducted to the RTO for exhaust gas cleaning. Diffuse emissions which are released during the filling and emptying process are collected by the room suction systems and generally channelled into the biofilters.

The fine treatment for separation into different fractions for thermal processing and for landfilling takes place in another hall.

In a separate building, fine treatment and compaction of the high calorific fraction into a refuse-derived fuel is carried out which is then loaded into a compaction container and transferred to the incinerator.

2.2 Emissions released in the different processing steps

All mechanical and biological processing steps are accompanied by more or less heavy emissions:

Table 2 Processing steps of the MBT-plant Neumünster and adjunct emissions

Component	**Processing step**	**main emission**
Lock	Entering of the lorry into the plant	Odours
Delivery hall	Unloading of the waste from the lorry into flat bunker, insertion into raw crusher by wheel loader	Dust, odours, exhaust gas, organic carbon
Treatment hall	General treatment and conditioning: comminution and pre-sorting of waste, irrigation of rotting fraction	Dust, odours
Composting hall	Filling and emptying of the composting units	Odours; organic carbon, NH_3, water vapour
Composting modules	Composting	Odours; organic carbon, NH_3, high concentration; water vapour
Fine treatment	Wind sieving	Odours; dust

3 Tasks and possibilities of aeration technology

Residents and the surroundings outside the plant have to be protected from the emissions stated under table 1. That is why the processing takes place in a closed plant. A special aeration concept, which is adapted to the plant's particular conditions and to the MBT-technology, was developed so that the personnel of the plant, the machines and the structure of the premises would not be exposed to excessive emissions. Basically, the aeration system is divided into the suction unit of the polluted air and the supply unit for fresh air. With the aid of the aeration system various effects are achieved:

Low-pressure especially in the area of the lock. This impedes that emissions are released to the outside via doors or natural leakages.

Collection of the exhaust gas in the hall and replacement by fresh air so as to guarantee the work safety. The directed supply of fresh air into the resting area additionally betters the work place conditions.

For avoiding condensation on metallic surfaces of parts of the units as well as the outer claddings of the halls, the suction system is designed in a way allowing to substantially discharge the considerable humid charges, which are released during the waste treatment process, through the aeration system.

By selective suction in places where the material is moved, arising dust is gathered and thereby the dust pollution inside the buildings is reduced.

3.1 Volume flow optimised aeration of the MBT-plant Neumünster

1. An especially effective possibility to reduce the volume flow is the optimisation of the volume of the hall. By optimising the arrangement of the different units and a sufficient but not exaggerated installation height, the volume of the hall was reduced in the MBT-plant Neumünster. The effect of this is that a sufficient air exchange, i.e. the complete exchange of the air in the hall, can be effected with a fairly low volume flow.

2. The structural separation of various work areas of the MBT-plant Neumünster (e.g. reception and composting halls) allows for each hall to be endowed with its own air exchange system.

3. The use of closed composting modules of the firm Biodegma facilitates the reduction of the exhaust gas volume flow to the absolutely necessary rate for the composting. Additionally, due to the monitoring conditions in the rot reactors, the rot time is cut down.

4. Multiple use of the collected exhaust gas

- The low contaminated exhaust gas from the reception and treatment hall is used as supply air for the composting hall. However, it is necessary to remove dust beforehand.

- The composting modules are supplied with the higher contaminated exhaust gas from the machines in the treatment hall which also has to be dedusted.

5. Varying exhaust gas quantities depending on the operating condition.

The suction process is divided into daytime and night-time operation. In detail this means that

- in times of shut-down, the reception and treatment hall can be subject to suction with a remarkably lower volume flow and that the suction of the machine technology is completely turned off.

- with resting unit parts, an automatic reduction or shut-down of the suction takes place (interconnection of the aeration flaps to the machine).

6. Encapsulation and source detection

The closer the exhaust gas suction system is brought to the source of emission

- the better for the quality of the air in the hall.
- the lower the necessary air exchange in the hall.
- the more concentrated the exhaust gas.
- the lower the required exhaust volume flow.

7. Targeted supply of fresh air

At the MBT-plant Neumünster, the supply air is specifically directed into the work areas. This leads to an increased air quality in these areas and the air exchange in the hall can be reduced.

The minimised exhaust gas volume flows also signify a decrease in the expenditures for installation and operation of the aeration technology and the exhaust gas cleaning system.

However, the minimised suction amount is disadvantageous for the obtained room air condition. The pollution within the premises with dust, odour and toxic substances only falls fairly below the admissible TLV. Humidity and heat is only partially and insufficiently discharged. This is an additional burden for the operating personnel and building services.

The multiple usage of the exhaust gas with the purpose of reducing the total exhaust gas causes the toxic substances to be carried over, especially the TOC load..

Even a sophisticated usage of the available exhaust gas is by far not sufficient so as to effectively avoid the emissions of dust and toxic substances of the mainly encapsulated machines into the hall. For this purpose, three to four times the quantity of air would have been desirable.

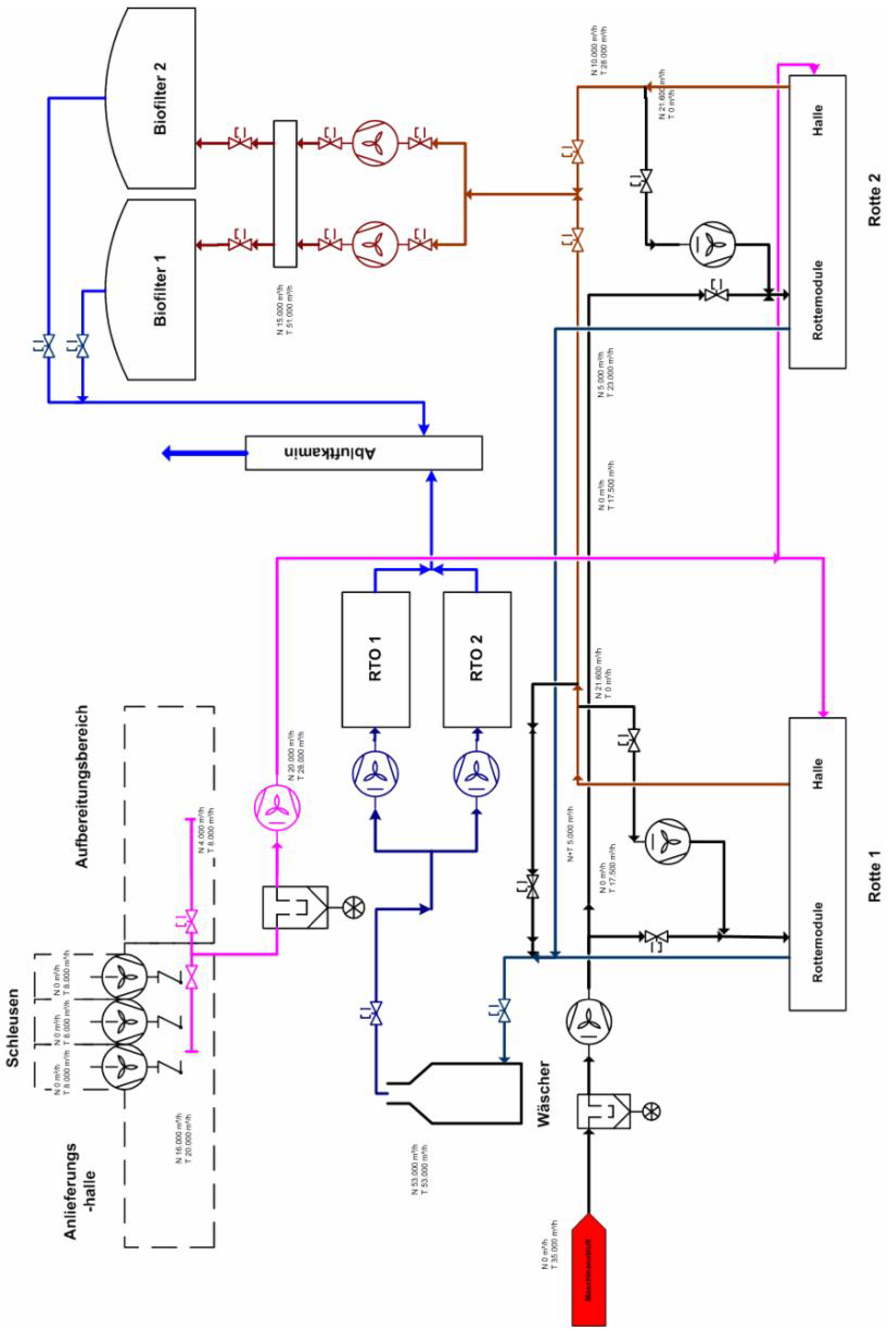

Figure 1 Plan suction with daytime and night-time operation and by-passes.

Anlieferungshalle	*Reception hall*
Schleusen	*Locks*
Aufbereitungsbereich	*Treatment area*
Abluftkamin	*Exhaust gas furnace*
Biofilter	*Biofilter*
Wäscher	*Scrubber*
Rottemodule	*Composting modules*
Halle	*Hall*
Maschinenabluft	*Machines exhaust gas*

4 Exhaust gas cleaning

The exhaust gas is divided into two different qualities:

- high-concentrated quality of direct suctions (machines, conveyors, composting modules) and
- low-concentrated quality of air in the hall.

The two qualities are released into the exhaust gas cleaning system via separated pipework systems. Due to this, the possibility arises to implement the technically and financially optimal procedure for the respective exhaust gas quality.

4.1 The applied exhaust gas cleaning methods

According to the authorisation notification, apart from odours and TOC also the laughing gas emissions shall be reduced. Laughing gas does not emerge during the waste processing but within the exhaust gas cleaning system. From waste, ammonia (NH_3) is released from nitrogenous compounds and collected together with the exhaust gas due to its volatility. With all oxidative operating procedures, be it biological, thermal or based on plasma technology, apart from organic substances the ammonia is oxidized. Amongst others nitrous oxide, the so called laughing gas, comes up. Laughing gas is a substance with a particular impact on the climate and also responsible for the greenhouse effect to a certain extent. Therefore, its formation and release in the exhaust gas cleaning process have to be prevented. This is done in a pre-separation of the ammonia load in an acid scrubbing.

4.1.1 Acid scrubber (Figure 2)

Ammonia can be removed from dirty gas by means of an acid scrubber. The formation of laughing gas is avoided due to a follow-up oxidative cleaning procedure. With diluted sulphuric acid, the ammonia is scrubbed as ammonium sulphate. At the MBT-plant Neumünster, the dosing of the sulphuric acid is aided by a pH-control device. The scrubbing dilution containing ammonium sulphate is discharged via an automatic elutriation unit.

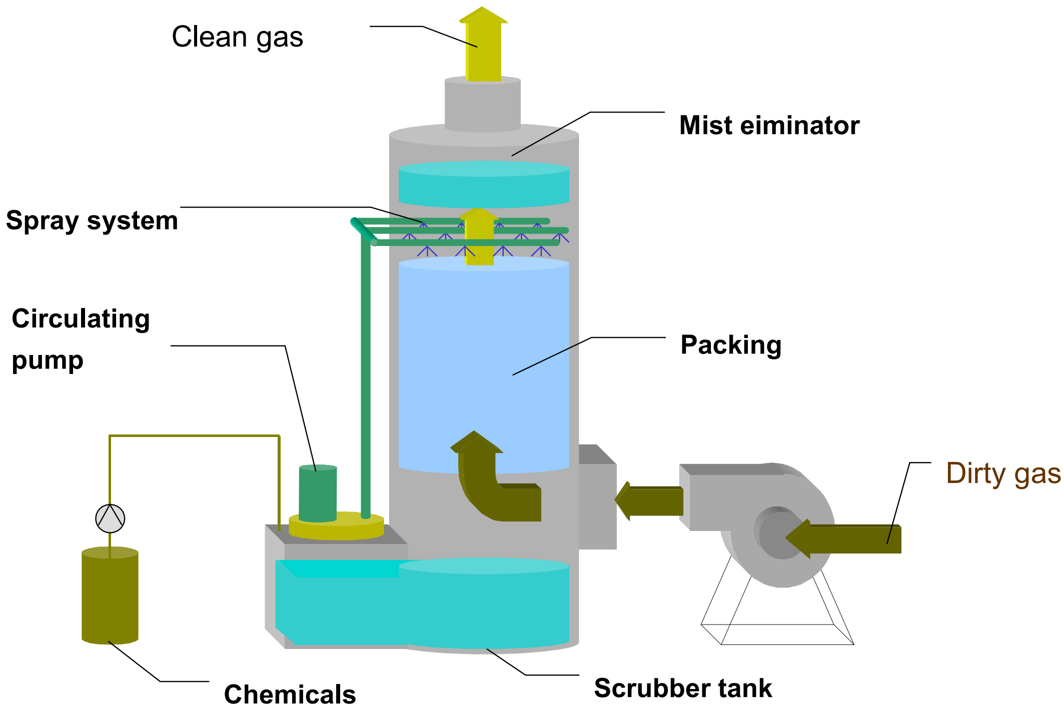

Figure 2 Acid scrubber

4.1.2 Biofilter (Figure 3)

Biological exhaust gas cleaning procedures, especially biofilters, are suitable for the reduction of odours. The air to be treated very slowly enters through an organic bed filter. For the plant in Neumünster a two layer construction was selected, consisting of grained, split burl wood as inflow layer and pre-fermented wood chips with a share of bark as main layer. It is a bed filter construction with a possibly low flow resistance, high efficiency and a long service life.

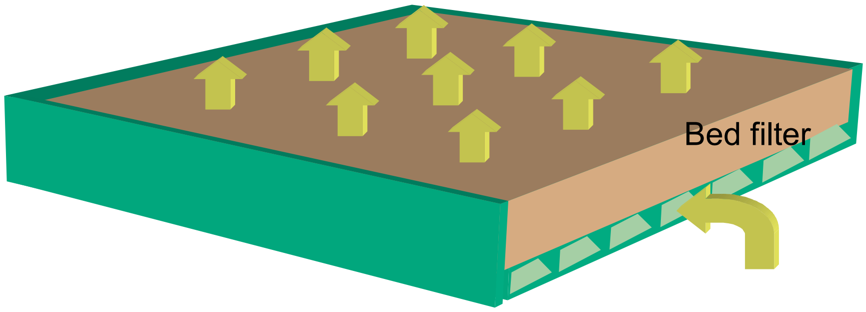

Figure 3 Basic scheme Biofilter

There is no problem for MBT-plants to comply with the exhaust gas temperatures necessary for the functioning of microbiology. Exhaust gas free of dust and almost water vapour saturated is a precondition for a trouble-free operation of the biofilters. For this purpose the exhaust gas is conditioned by means of a preceding scrubber, i.e. humidified and precipitated and if necessary the ammonia is scrubbed by an additional dosage of sulphuric acid.

With regard to the reduction of odour both the low-concentrated exhaust gas of the halls as well as the higher concentrated composting air could be treated with biofilters. But, due to the low, mass-related limit value for TOC this is not possible because with the admission of pure air, the biofilter already emits a certain basic amount of organic compounds resulting from the non-specific biodegradation of the filter material itself. Furthermore the possible degradation of TOC is limited to 40-60%; methane is basically not degraded at all.

Rightfully, the natural emission should not be included into the emission balance of the biofilter, because the filter material is taken from nature and would also be degraded if remaining in nature. Furthermore, this emission is to be confronted with the carbon emission by using primary energy with thermal processes. However, since the natural emission in terms of measurement technology cannot be distinguished from the remaining emission from the exhaust gas, the total emission is considered in the assessment. In order to not exceed the emission limit values, exhaust gas with a high concentration of TOC is conducted to a procedure with lower remaining emissions of organic carbon (not CO_2!).

4.1.3 Regenerative Thermal Oxidation (RTO) (Figure 4)

For the reliable compliance with the mass-related limit values for TOC, the high concentrated exhaust gas is cleansed by means of an exhaust gas incinerator. In the case of the implemented method of the regenerative thermal oxidation (RTO), only relatively small amounts of primary fuels are necessary, since the heat contained in the exhaust gas is used in order to warm up the dirty gas to be cleansed. A technique with a particular high thermal efficiency was selected. The facility already runs in an autothermic range with relatively low concentrations of organic compounds in connection with dirty gas. With concentrations below the autothermic range, this procedure, however, is much more expensive than a biofilter. The RTO is preceded by an acid scrubber for the elimination of ammonia and the prevention of the formation of laughing gas.

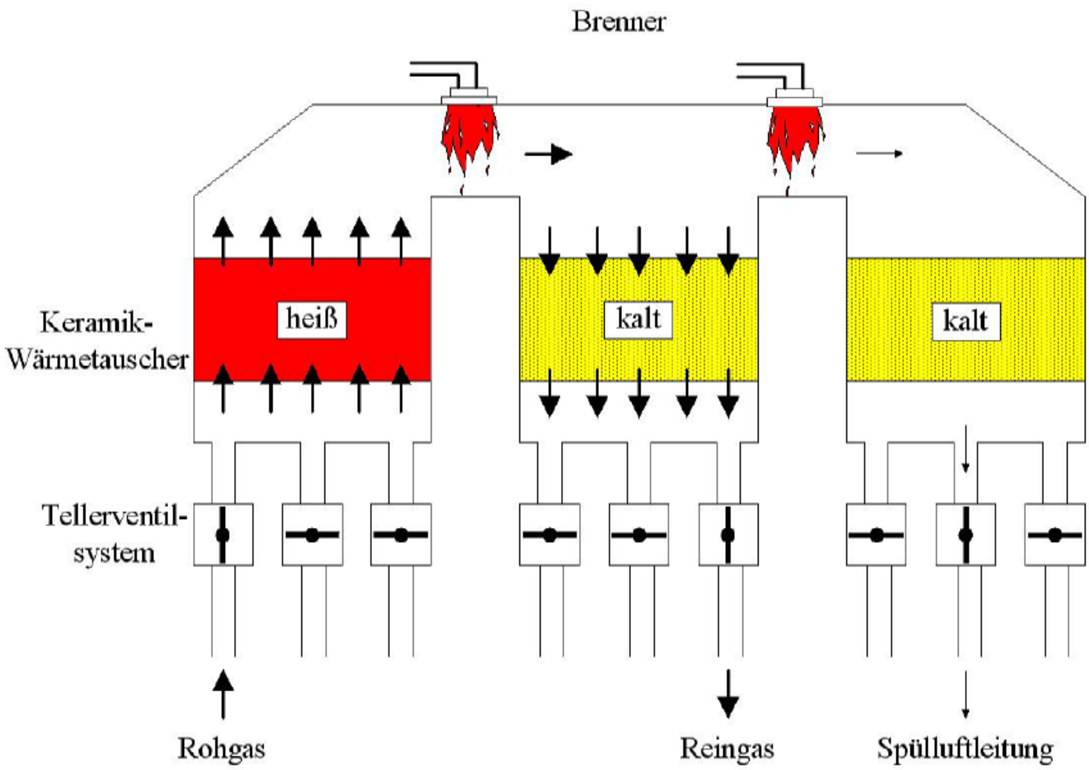

Figure 4 Basic scheme RTO

Brenner	*Burner*
Keramikwäremetauscher	*Ceramic heat exchanger*
heiß	*hot*
kalt	*cold*
Tellerventilsystem	*Disc valve system*
Rohgas	*Dirty gas*
Reingas	*Clean gas*
Spülluftleitung	*Scavenging air pipe*

In practice, the high thermal efficiency of the incineration is achieved by a close-meshed honeycomb heat exchanger, which requires a mainly dust-free exhaust gas.

In the case of the MBT-plant Neumünster, it became evident that the dust removal in the preceding scrubber is done efficiently, but nevertheless, notable depositions evolve within a very short time on the honeycombs. Studies have shown that these depositions are SiO_2 accruing with the combustion of siloxanes, which are released in considerable quantities from the silicon compounds contained in waste.

The silicon oxide formed in the gas phase is accrued in the honeycombs and increases the loss of pressure and thus the electrical energy demand of the aerators. Not least, the maintenance efforts for cleaning the honeycombs are remarkably extended.

4.2 Flexible exhaust gas management of the MBT-plant Neumünster

The concentration of exhaust gas varies with the work situations accordingly. By-pass ducting allowing an automatic switch-over depending on TOC concentration and work situation was installed, so that the expensive RTO procedure is not implemented for the exhaust gas from the direct suctions when these occur in a work phase with low pollution. If the biofilter is not working at full capacity, the exhaust gas from direct suction can be diverted and the RTO will be relieved. In order to variy the RTO exhaust gas quantity in great tolerance ranges, the RTO in Neumünster is designed in two lines. With the reduction of the dirty gas flow of the RTO, one of the two lines can be shut off. Simultaneously, the mandatory redundancy is achieved.

In order to also scrub higher ammonia concentrations in the dirty gas e.g. by partial admission with exhaust gas from the direct suction, the preconditioning of the biofilter was designed in a way that in such a case the preceding scrubbers function as acid scrubbers. By means of the pH-control system, the dosage of diluted sulphuric acid is monitored.

4.3 Redundancy and availability of the exhaust gas cleaning systems

1. With the selection of the materials in Neumünster, a special eye was kept on the corrosion resistance in order to prevent unnecessary repair works.

2. The selection of low-maintenance components of the exhaust gas cleaning unit allows an increase in availability. This especially holds true for the

   - dust filters with automatic dust discharge
   - surface biofilter with short downtimes during material changes

- long-life filter material
- automatic control system of the acid scrubber

3. To avoid gaps in the exhaust gas cleaning process during maintenance and servicing, the two cleaning procedures were designed with two lines each. The RTO is designed with a capacity of 150% (pursuant to 30^{th} BImSchV).

Not only the biofilter's chamber was built up in a modular manner but also the preconditioning: Each of the two biofilters is endowed with an own scrubber and aerator.

The existing by-pass ducts between the two exhaust gas cleaning procedures RTO and biofilter allow switching over respectively to the other cleaning system in case of downtime of a line. Additionally by-pass ducts of the preconditioning were arranged so that these can be shut down during a short period without having to shut down the entire line.

However, particularly with the SiO_2-problem with the RTO an increased maintenance effort and respective downtimes is necessary.

Due to the closed structure, observing and maintenance of the biofilters is made difficult. A functional check during operation is almost impossible. An open biofilter would be more advantageous.

The dust load of the machine exhaust gas being higher than assumed in planning and the insufficient amount of exhaust gas lead to an increased cleaning effort.

5 Conclusions

The suction system of an MBT-plant has to be optimised even in the planning stage with regard to the volume flows to be removed. This can be achieved by having the machine suppliers constructively provide the suction points and placing them as close as possible at the emitting sites. Nevertheless, it should be observed that the limits of feasibility are not exceeded. Low air exchanges automatically lead to a decrease of the quality of the air of a room and too narrowly dimensioned buildings have a negative impact on the accessibility of the plant equipment and barely provide possibilities for later adjustments of procedures or expansion.

The operator has to define the different operation conditions of the whole plant so that the saving potential for various work and load situations can be fully exploited.

The multiple use of the removed gas is indispensable in order to prevent exceeding the specified exhaust gas amount. However, the carry-over of pollution, not just of dusts has to be considered in this respect.

The interconnection of the flap control system with the suction machine and the aerators with frequency transformers open the way for further saving potential.

The greatest possible flexibility is to be considered in planning for exhaust gas cleaning system, because this allows to save redundancy and operational costs. This is achieved by means of the by-pass ducting and the modular structure of the facilities.

The implementation of a thermal exhaust gas cleaning system is imperatively necessary in order to comply with the specified limit values for TOC, but also represents a considerable share of the investment and operational costs. By all means it should be reconsidered whether it really makes sense in ecologic terms to use valuable primary energy so as to reduce the already low TOC emissions to a minimum. Such procedures also lead to the fact that total CO_2- balance of the MBT-technology rises notably which would be counterproductive in the long run.

6 Literature

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Author's address

Dipl.- Ing. Thomas Pfliegensdörfer, Dipl.- Ing. Ralf Bisdorf
Tholander Ablufttechnik GmbH
Werkstrasse 31
D-68519 Viernheim
Phone: +49 6204 92923 0
Email: info@tholader.de
Website: www.tholander.de