LÜHR FILTER

From pocket-type filter to flat-bag filter – Development, types, separation efficiency

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Content

1 From pocket-type filter to flat-bag filter

Together with the development of needle felts, not only flat-bag filters had been available as fabric filters for the separation of particles from air and gases but also pocket-type filters with a pocket sizes of up to 2,000 x 2,500 mm. Compared to the bag filter constructions, these types of filter presented, beside a few advantages, some aggravating disadvantages:

- Smaller throughput capacity due to a bad cleaning behaviour
- Shorter filter material service lives, as a result of high mechanical stress in some areas of the needle felt pockets
- Unfavourable handling of pockets during dismounting and mounting.

Based on the evidently existing physical advantages of the pocket-type filter construction, LÜHR FILTER developed the flat-bag filter in several steps of construction. This variant of fabric filter combines the advantages of the bag filter construction with the ones of the pocket-type filter, avoiding at the same time the above-mentioned disadvantages of the pocket-type filter. Since more than 25 years flat-bag filters have been successfully used in different fields of use for

- the separation of particles
- the absorption of acid crude gas components such as HF, HCl and SO_x
- the adsorption of dioxins/ furans and heavy metals, such as mercury and mercury compounds.

This type of fabric filter offers amongst others the following advantageous features:

- high separation efficiency
- above-average filter fabric service lives due to low mechanical stress of the sensitive needle felt
- excellent regeneration of filter fabric during cleaning of filter surface
- simple handling during mounting and dismounting of filter bags

The following lecture presents the construction of the flat-bag filter and demonstrates the advantageous features as well as the multifunctional fields of use.

2 Construction of flat-bag filter

2.1 General structure

The fundamental design of the flat-bag filter with horizontally installed filter elements is shown in illustration 1.

The filter housing is subdivided into crude gas and clean gas chamber by means of perforated plates. The flat-bag elements, each consisting of flat-bag and support cage, are installed from the clean gas side. The filter elements are fitted precisely in fixed positions in the holes of the perforated plate, secured without the use of screws, providing perfect seal against dust leaks. The crude gas flow through the textile filter material is from outside to inside, thus retaining the particles on the outside.

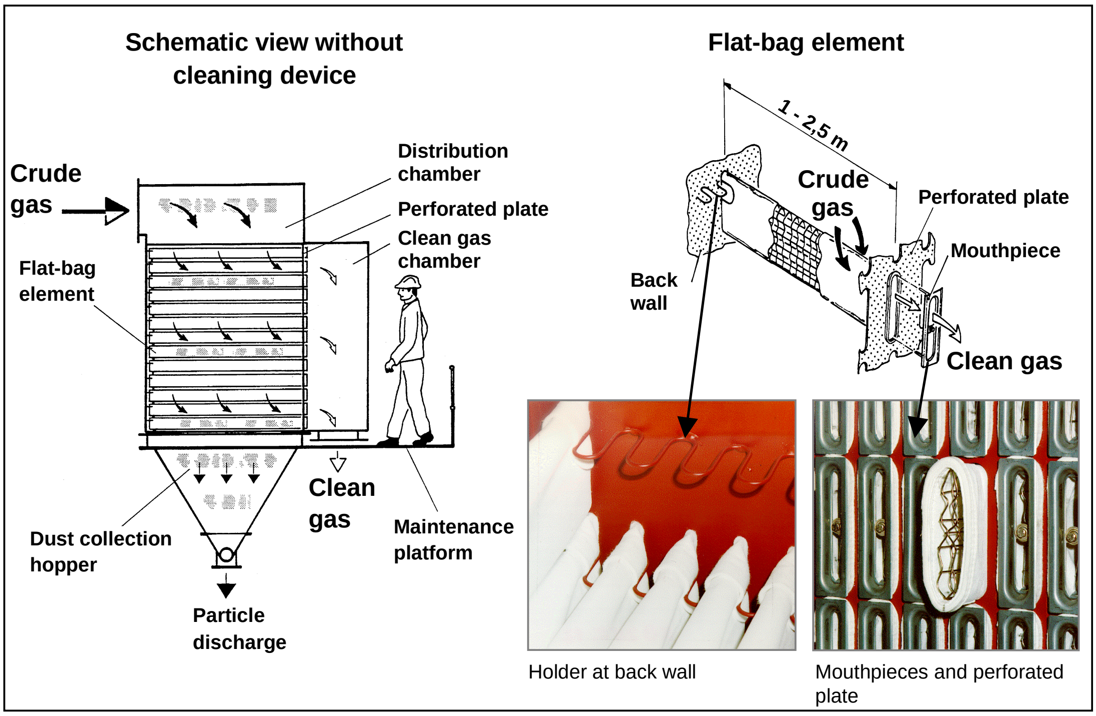


Illustration 1: Schematic view of flat-bag filter and flat-bag elements (horizontal installation)

It may be remarked in addition, that alternatively a version with vertically installed flat-bag elements is available (illustration 2). Even with regard to this filter design, the flat-bags are also hold in fixed positions within the housing, however, not all advantages of the flat-bag filter with horizontally installed filter elements can be used consequentially.

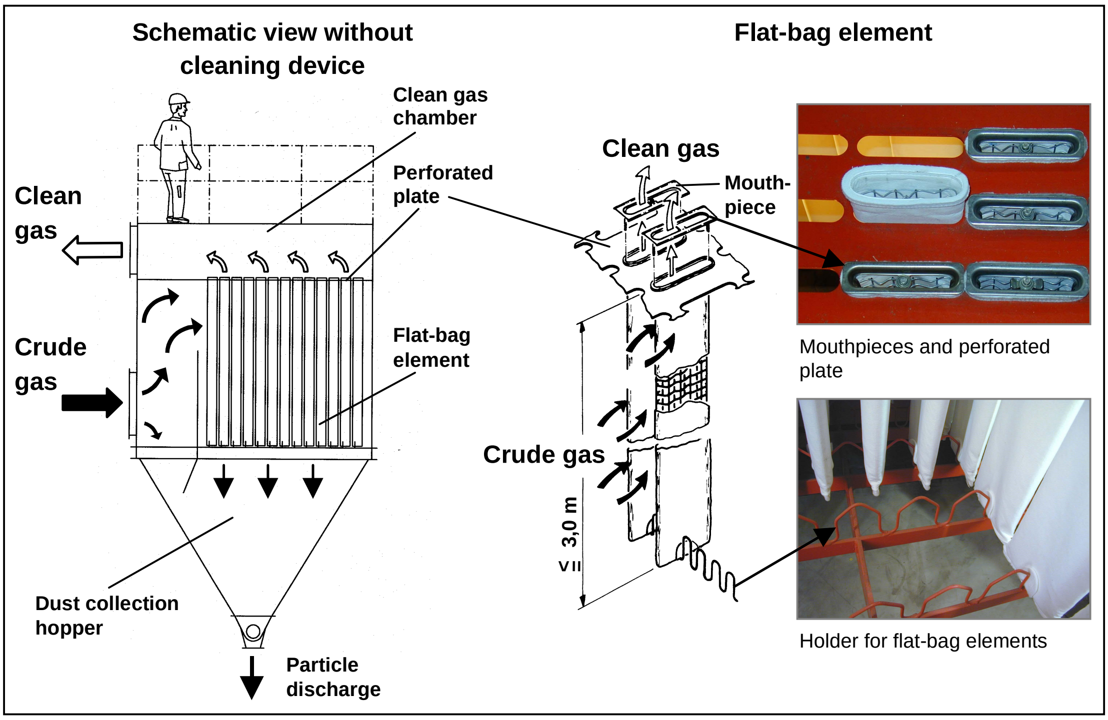


Illustration 2: Schematic view of flat-bag filter (vertically installed flat-bags)

2.2 Cleaning systems

Different cleaning systems are available for the separation of particles deposited on or embedded within the filter fabric. Four types of cleaning systems, frequently used for flat-bag filters, are described in the following, without assessment of the advantages and disadvantages.

2.2.1 Compressed air – on line – cleaning (illustration 3)

The clean gas chamber is provided with vertically installed, easy to remove compressed air injectors, arranged in front of each bag row. Compressed air and clean gas as secondary gas are injected sequentially into two adjacent bag rows by means of injectors, designed in accordance with aerodynamic principles. The bag rows are cleaned in pairs by a brief pulse of jet air, injected into the bags contrary to the filtration flow, thus removing the particle cake from the fabric filter.

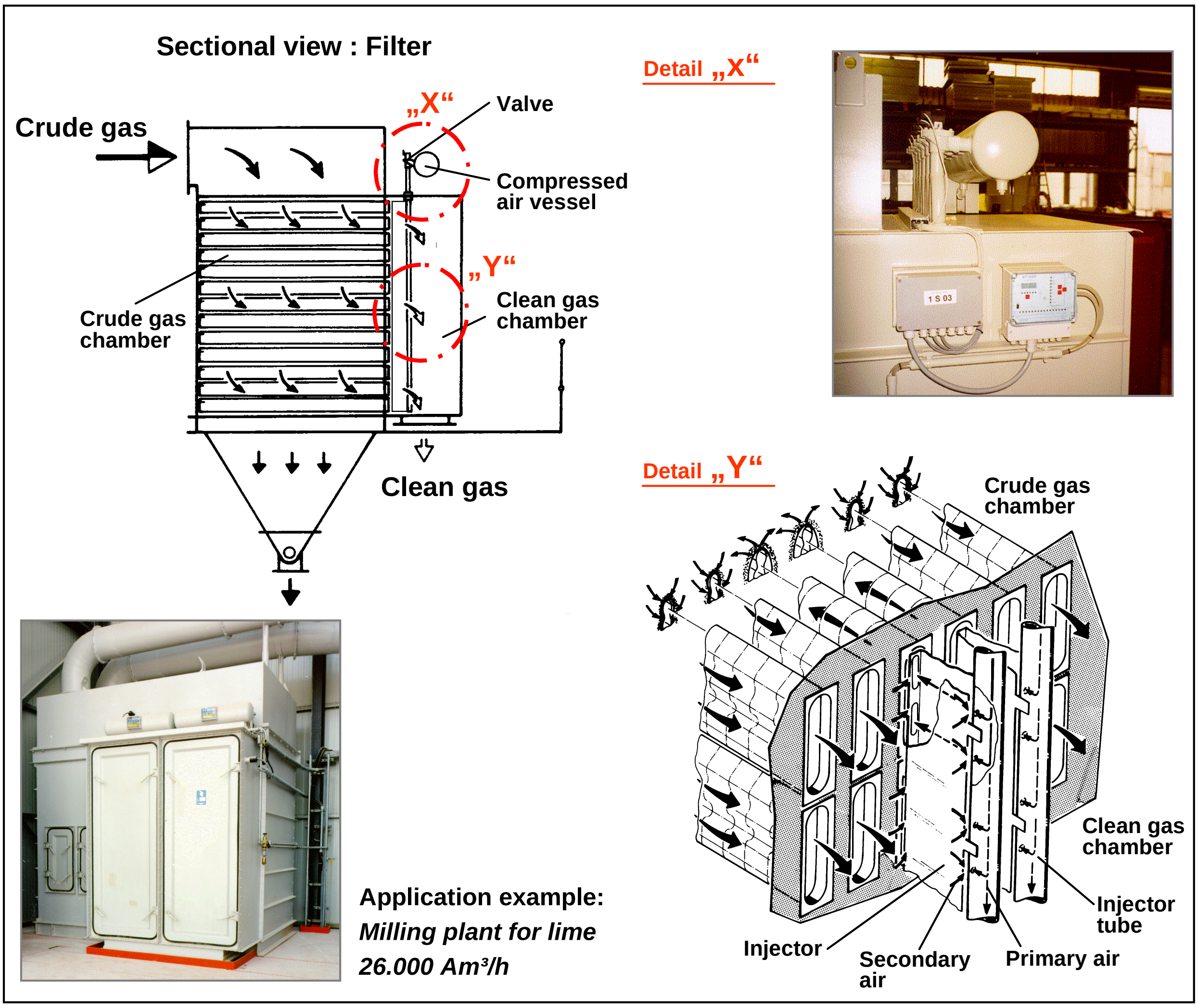


Illustration 3: Compressed air – on line – cleaning

2.2.2 Compartmentalised compressed air – off line – cleaning

The fundamental design of this type of cleaning system is demonstrated in illustration 4, exemplary shown by means of a flat-bag filter with vertically installed flat-bags.

The clean gas chamber is divided into several compartments. Each compartment is connected to the clean gas collective channel and can be isolated. At the beginning of the cleaning process of one compartment the corresponding isolation damper on the clean gas side is closed. The flat-bags are cleaned by means of compressed air in the pre-described manner during interrupted filtration process.

On request, the complete crude gas chamber of the filter housing can also be divided into compartments, thus offering the possibility to shut down separate compartments for inspections and/or repair works while the other compartments remain in operation. In principle this procedure will also be applicable to the compressed air – on line – cleaning system.

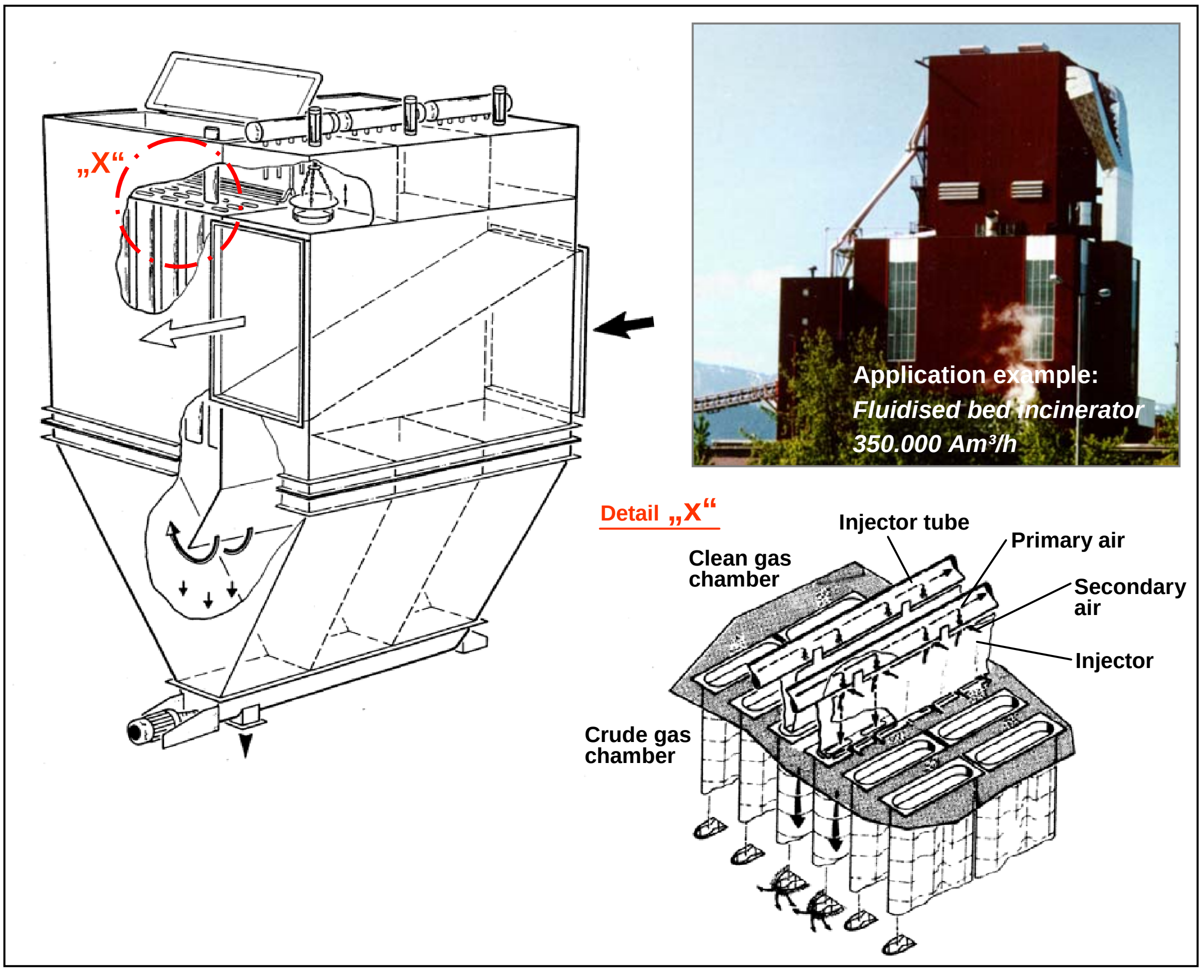


Illustration 4: Compartmentalised compressed air – off line – cleaning

2.2.3 Travelling compressed air – off line – cleaning (illustration 5)

The cleaning of the flat-bag rows is effected sequentially in steps by means of a cleaning device, travelling within the clean gas chamber and provided with compressed air feeding and injector tubes. The cleaning device covers three vertical filter bag rows, the middle of them being cleaned with a brief, about 0.5 sec., pulse of jet air and clean gas as secondary gas. A lip seal along the carriage travel serves as reliable sealing, proved in continuous operation.

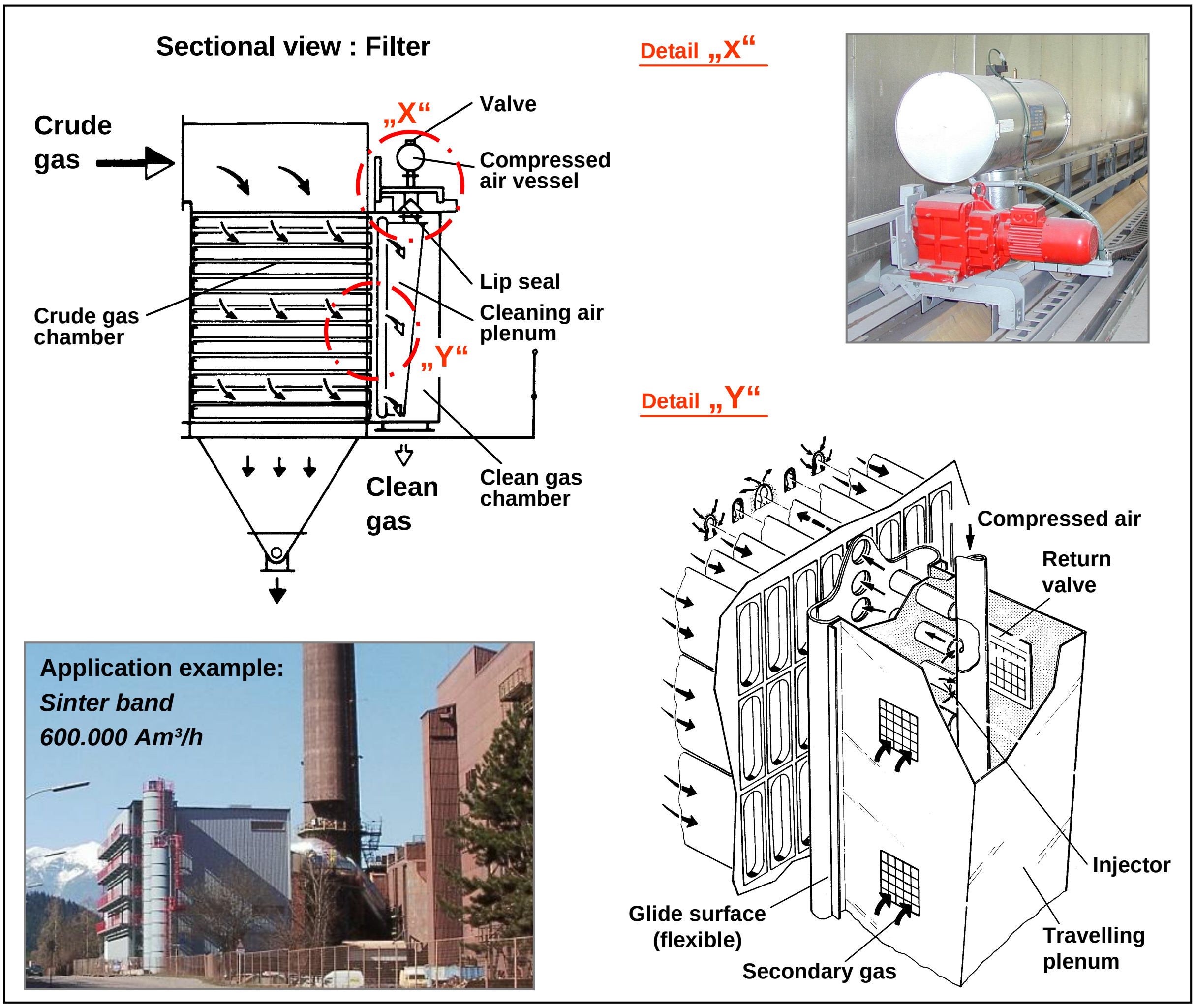


Illustration 5: Travelling compressed air – off line – cleaning

2.2.4 Travelling medium pressure – off line – cleaning (illustration 6)

The cleaning of the flat-bag rows is effected sequentially in steps by means of a cleaning device, travelling within the clean gas chamber. The cleaning air is injected into one flat-bag row by means of a medium pressure fan. The two bag rows adjacent to the row being cleaned are not charged by the crude gas during the cleaning process. A lip seal along the carriage travel serves as reliable sealing, proved in continuous operation.

This cleaning system does not require any compressed air.

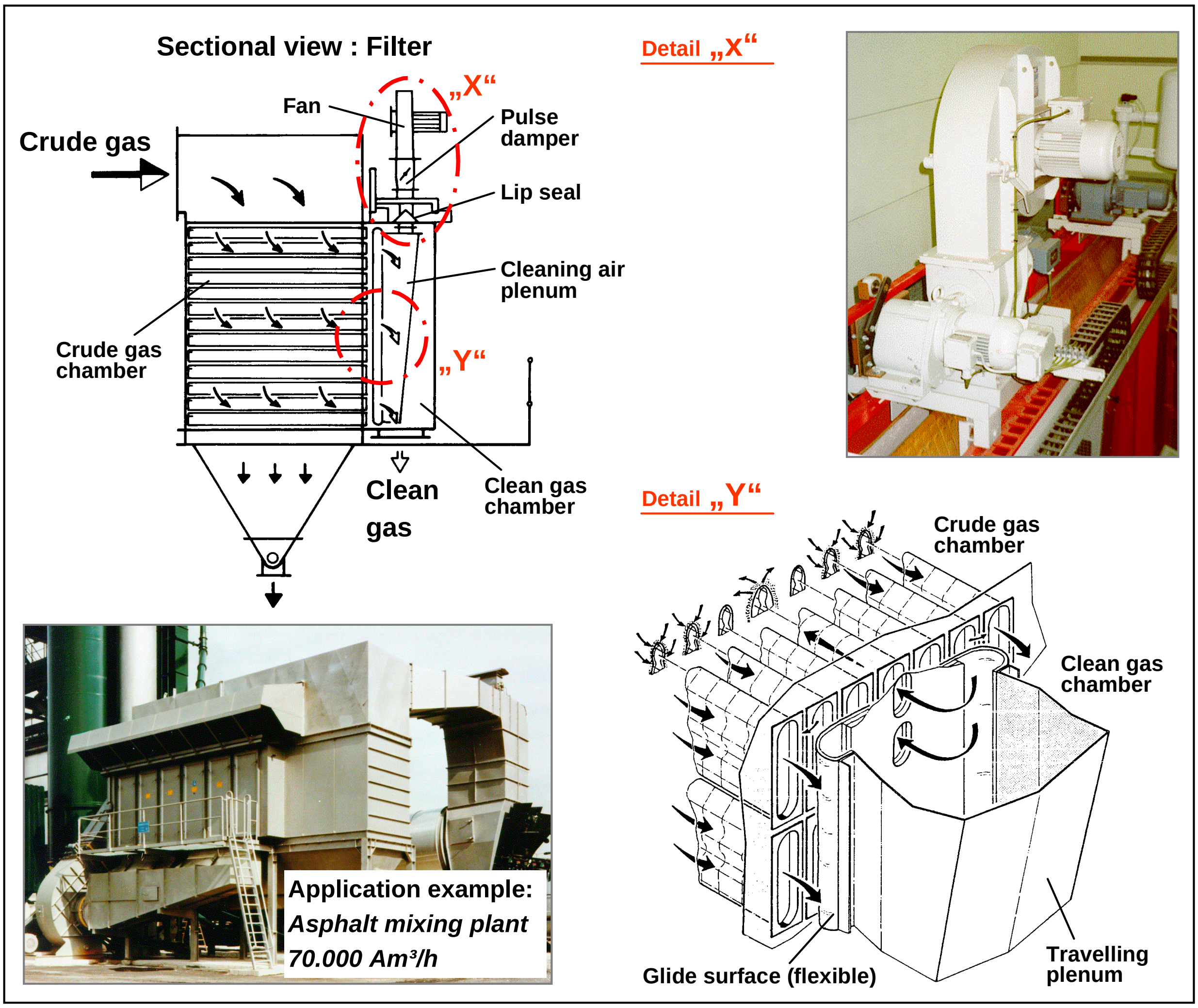


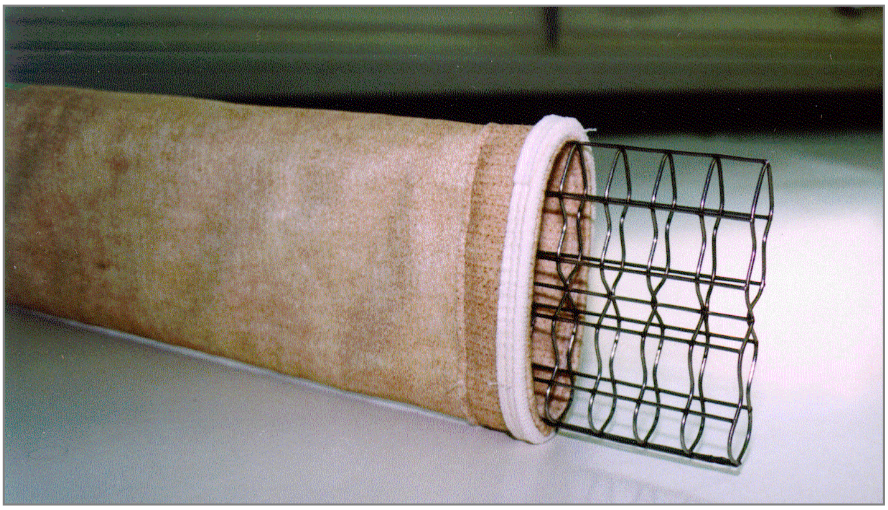
Illustration 6: Travelling medium pressure – off line – cleaning

3 Advantageous features for achieving low residual particle contents in the clean gas with above-average filter fabric service lives

Flat-bag filters are well-suited for granting low residual particle contents in the clean gas with at the same time very long filter fabric service lives. Compared to other filter constructions, this is amongst others due to low mechanical stress of the filter fabric. Some corresponding aspects are mentioned below.

3.1 Support cage construction

The used support cages have a small wire mesh (approx. 25 x 25 mm) (picture 7), thus achieving on the complete filter fabric an almost homogeneous distribution of the forces which are acting on the filter bags as a result of the filter differential pressure.



Wire mesh:
approx. 25 x 25 mm

Picture 7: Support cage of flat-bag filter element

The dimension of the arising forces can be described by means of a simple example: a filter differential pressure of 15 mbar (the same as 150 mm WG) corresponds to a load of 1,500 N/m². These surface forces have to be transmitted to the wires of the support cages by means of the filter fabric. The smaller the mesh, the lower is the load on the textile filter fabric near the wires.

3.2 Length of flat-bag filter elements

With regard to the flat-bag filter construction, the length of filter elements is limited to 2.5 m for the horizontal installation and to 3.0 for the vertical installation. In comparison to other types of construction, this limitation requires - on one hand – the installation of proportionally more filter elements for a filter surface of the same size, on the other hand, however, it offers considerable advantages:

- Better distribution of the used cleaning energy on the complete filter surface
- The filter housings can be transported to construction site with already installed filter elements (picture 8)
- The separate filter elements are easy to handle
- No divided support cages are used

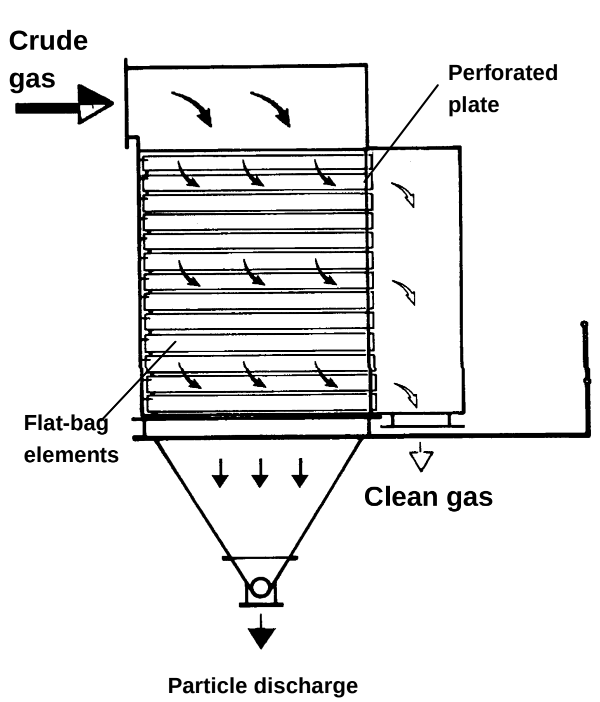
Picture 8: Filter on low-loading truck for road transport

3.3 Filter inlet to the filter elements (illustration 9)

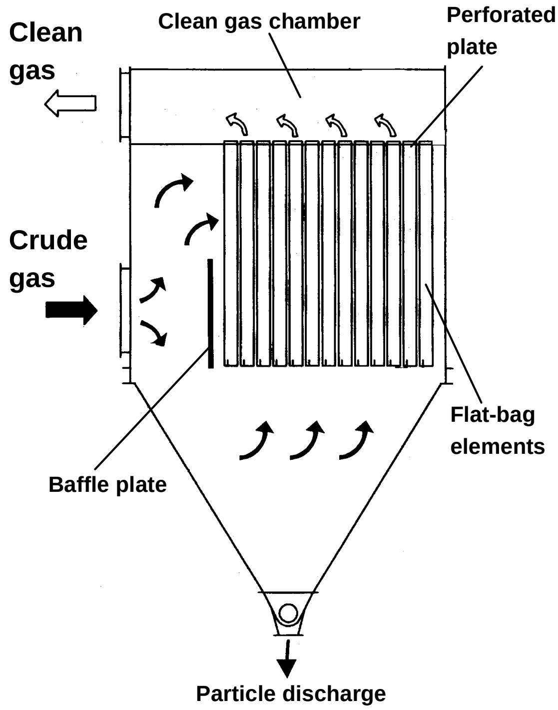
An important condition for the achievement of long cleaning cycles and as a result of this low stress of the filter fabric is the preferably undisturbed descent of the separated particles within the filter housing.

In case of use of one compartment filters, a crude gas inlet from above should be preferred.

In one compartment filters with a crude gas inlet from below or diagonally from below the particle agglomerate separated from the filter fabric can only descent if its descent velocity is higher than the gas inlet in counter flow. Due to the fact that the descent velocity of particle agglomerates of about 200 µm is only approx. 1 m/sec., it is evident that one compartment filters should exclusively be provided with a crude gas inlet from above in order to avoid an undesired and uncontrolled redeposit of particles, especially of finest particles.



Crude gas inlet 100 % from above
Downstream principle favours the falling down of particles into the collection hopper.



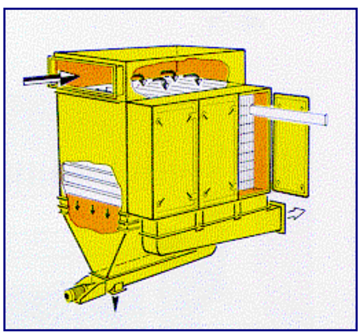
Crude gas inlet from above and below
The partial inlet from below prevents especially the fine particles from falling down into the collection hopper.

Illustration 9: Different types of crude gas inlet to the flat-bag filter elements

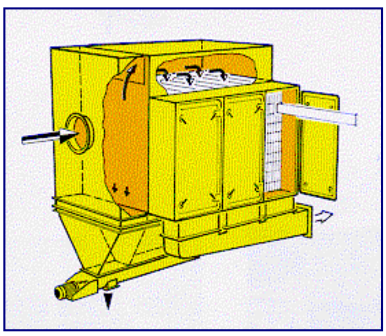
In order to achieve an almost homogeneous crude gas inlet to the filter element rows and/or for the pre-separation of coarse particles, it may be useful to provide the filter with an integrated inlet or pre-separation chamber (illustration 10).

Entry from above

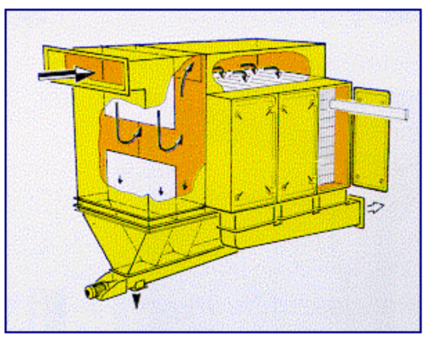
(only possible with horizontally installed flat-bag elements)



from above



from above via inlet chamber



from above via coarse particle pre-separation chamber

Illustration 10: Available alternative designs of crude gas inlet

3.4 Cleaning systems

Illustration 11 demonstrates the influence of the cleaning procedure on the residual particle content in the clean gas. The graph shows the continuously measured residual particle content in the clean gas as well as the filter differential pressure over the time. The data have been measured at a filter with a comparatively small filter surface.

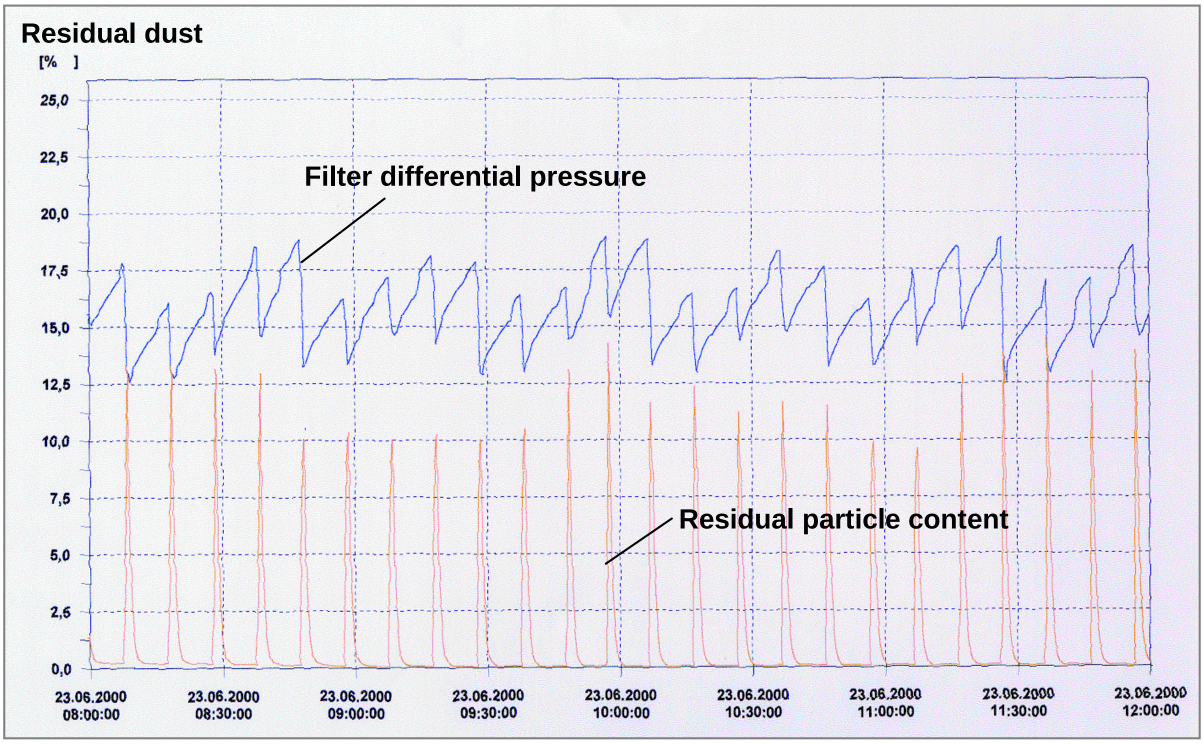


Illustration 11: Influence of the cleaning cycle on the residual particle content in the clean gas

It is clearly visible that after each – on line – cleaning procedure there is an increase in the particle passage, which fairly quick falls down to a low level again. This is due to the „carpet tapping effect“. After closing the compressed air injection, the filter fabric is pressed onto the support cage as a result of the filter differential pressure. When reaching the support cage, the filter fabric is slowed down abruptly and the loosely deposited particles arrive in the clean gas chamber.

The residual particle content can be reduced by:

- An extension of the cleaning cycle (however combined with an increase in the filter differential pressure)
- The utilisation of an – off line – cleaning system, by means of which the filter bag is smoothly led back onto the support cage.

The already presented medium pressure and compressed air – off line – cleaning systems with a travelling cleaning device in the clean gas chamber, are favourably priced flat-bag filter types. They benefit from the advantages of the - off line –

cleaning systems, without having to accept the disadvantageous complex construction of the compartmentalised – off line – cleaning system.

3.5 Effects on the filter fabric selection

The above-described special features of the flat-bag filter allow that in most of the fields of application, high degrees of separation and extremely low residual particle contents in the clean gas can be achieved even without the utilisation of filter fabrics with expensive surface membranes or surface treatments.

Furthermore, flat-bag filters are suitable for the utilisation of filter fabrics with low specific weights and a high specific air permeability.

4 Separation of non-particulate gas contents

As standard practice, fabric filters can only separate particles from gas. In order to be able to separate gaseous substances, these substances have to be converted into the particulate form by injecting additive powders (absorption) or have to be deposited on or embedded in additive particles (adsorption).
Examples are:

- Absorption of acid crude gas components such as HF, HCl and SO_x by means of injection of additive powders based on Ca- or Na-compounds
- Adsorption of dioxins/furans by means of injection of additive powders with large, internal surface such as e.g. open-hearth furnace coke, activated carbon or special clay minerals
- Ab-/ adsorption of gaseous heavy metal compounds by means of one or several of the pre-mentioned additive powder qualities

Ab- and adsorption make great demands on the efficiency of fabric filters. Sufficient degrees of separation can only be achieved if

- a contact between crude gas molecule and additive particle is granted (homogeneous distribution of particles) and
- if the additive particles are as far as possible retained at the filter fabric

The separation of dioxins/furans demonstrates very clearly the high requirements which are made on the construction of fabric filters. A corresponding application example is shown in illustration 12. The dioxin/furan concentration in the gas upstream filter totals to approx. 5 – 10 ng/Nm³. The requested clean gas value is about < 0,4 ng/Nm³.

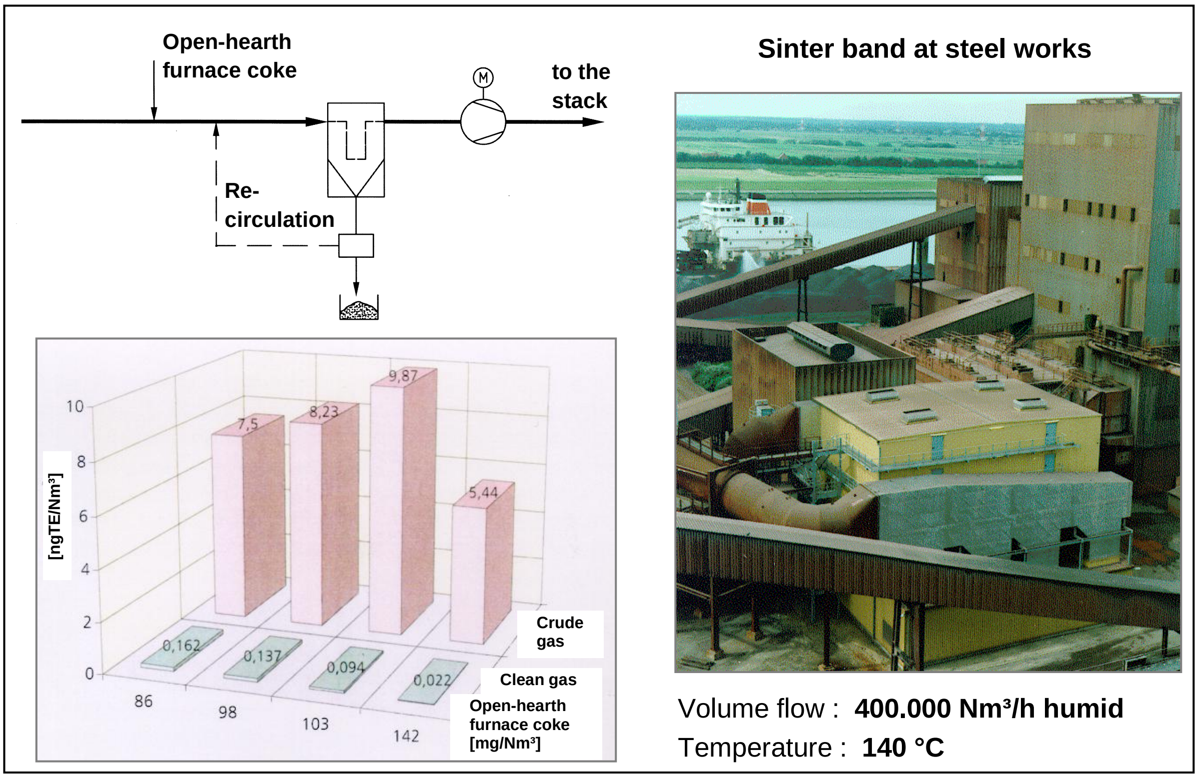


Illustration 12: Application example for dioxin/furan separation

Measurements have proven that with regard to this application, more than 95% of the dioxin/furan compounds were present in gaseous form and could only be separated by means of injection of additive powders with a large internal surface. During measurement, the residual particle content in the clean gas was ≤ 1 mg/Nm³.

Compared to the usual requirements on fabric filters, the requested degree of separation for dioxins/furans of 92 – 96% is comparatively low. However, when considering the given concentrations of the dioxin/furan compounds to be separated, the difficulty of this type of application becomes clear. The clean gas value of 0.4 ng/Nm³ corresponds to a value of 0.000.000.000.4 g/Nm³. It is evident that a reduction of dioxins/furans to such a low value can only be achieved if the additive particles within the filter are homogeneously distributed and if the requested residual particle content in the clean gas is definitely lower than the usually requested values. Flat-bag filters are particularly suitable for these requirements.

5 Application example

The multifunctional utilisation of the fabric filter for the separation of gaseous and particulate components of gases can be exemplary shown at a crude gas cleaning downstream grate bar firing with downstream installed boiler for the incineration of domestic waste. Illustration 13 shows the plant structure, table 1 the crude gas and clean gas values as well as the requested degrees of separation.

It is remarkable that for the increase in efficiency during the separation of gaseous substances, the particles separated in the filter are frequently re-introduced in the crude gas flow upstream filter. As a result of this re-circulation, the particle content upstream filter totals to approx. 250 g/Nm³. The resulting, actually necessary degree of particle separation for achieving the requested emission limiting values totals to > 99,996%.

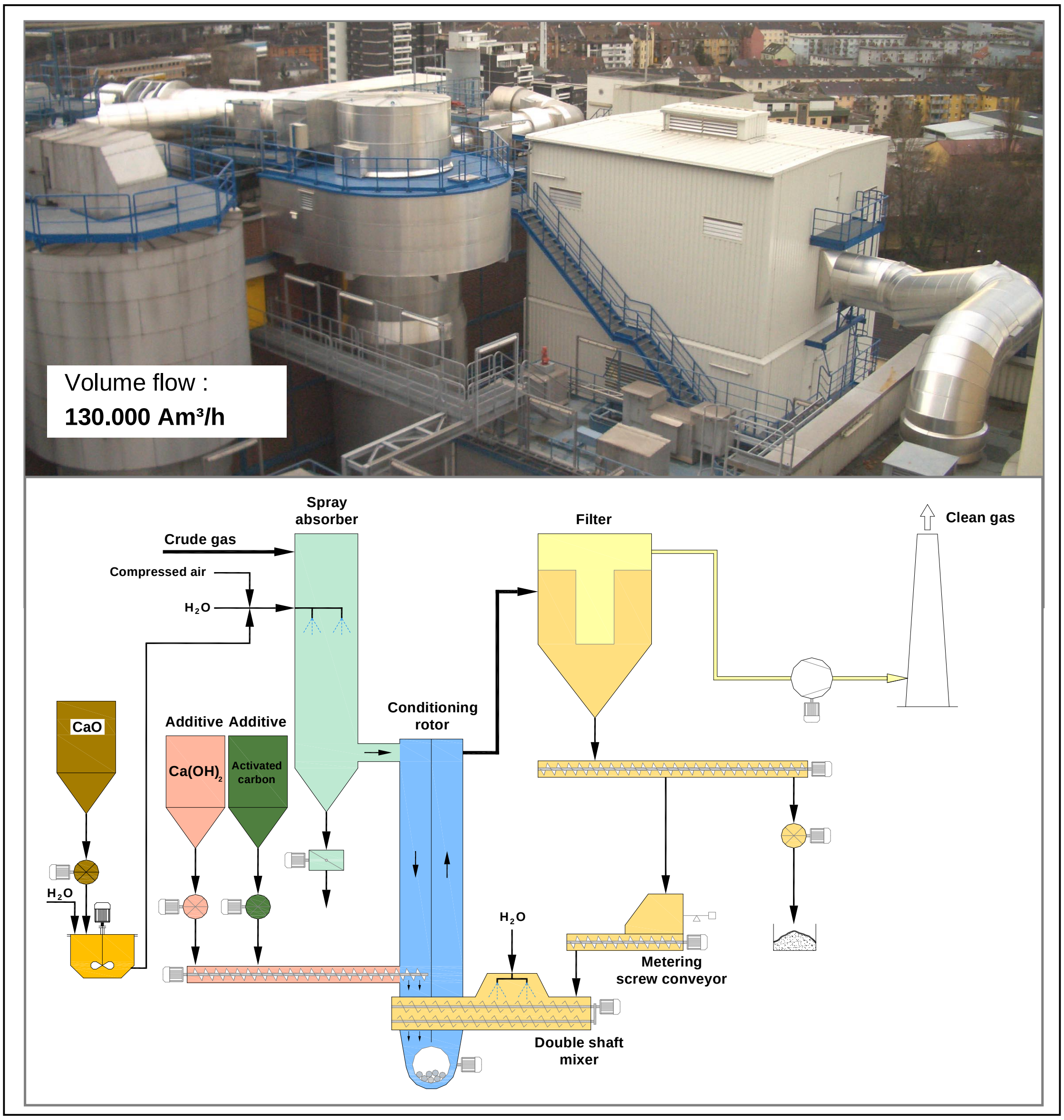


Illustration 13: Application example: domestic waste incinerator

		Gas take-over		Emission limit values		Degree of separation [%]	
		DAV *	HAV **	DAV	HAV	DAV	HAV
Overall dust	**[mg/Nm³ dry]**	**1.600**	**5.000**	**10**	**20**	**> 99,4**	**> 99,6**
HCL	**[mg/Nm³ dry]**	**1.000**	**2.000**	**10**	**60**	**> 99**	**> 97**
HF	**[mg/Nm³ dry]**	**15**	**30**	**1**	**4**	**> 93,3**	**> 86,7**
SO_2	**[mg/Nm³ dry]**	**400**	**600**	**25**	**150**	**> 93,8**	**> 75**
Hg	**[mg/Nm³ dry]**	**0,3**	**0,3**	**0,015**	**0,03**	**> 95**	**> 90**
Cd + Tl	**[mg/Nm³ dry]**	**1,0**	**3,0**	**0,05 *****		**> 95**	**> 98,3**
Σ (Sb, As, Pb, Cr, Mn, Ni, V, Sn)	**[mg/Nm³ dry]**	**20**	**50**	**0,5 *****		**> 97,5**	**> 99**
Dioxin / Furan	**[ngTE/Nm³ dry]**	**3,0**	**5,0**	**0,1 *****		**> 96,7**	**> 98**

***** Daily average value ****** Half-hour average value ******* Average value over sample taking period

Table 1: Requirements on a fabric filter, exemplary shown at a domestic waste incinerator

6 Assessment

In principle, fabric filters are suited to meet, in continuous operation, the today's and future requirements concerning the requested degrees of separation for particles and other gaseous components. When selecting the type of fabric filter for a given application, the different filter constructions have to be assessed by comparison. The criteria to be considered are amongst others:

- the resulting investment costs
- the arising operating costs, such as e. g. energy and compressed air consumption, expenditure of maintenance, filter fabric service life, etc.
- availability and reliability
- references

Especially the operating costs and the achievable availability are influenced by the filter construction. The aim is to select a variant, which will among other things

- minimise the mechanical stress of the filter fabric,
- allow long cleaning cycles,
- keep the concentration of finest particles near the filter fabric as low as possible,
- achieve a comparatively low filter differential pressure.

The aforementioned specification has given hints in this respect.

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