LÜHR FILTER

The application of fabric filters to glass manufacturing processes

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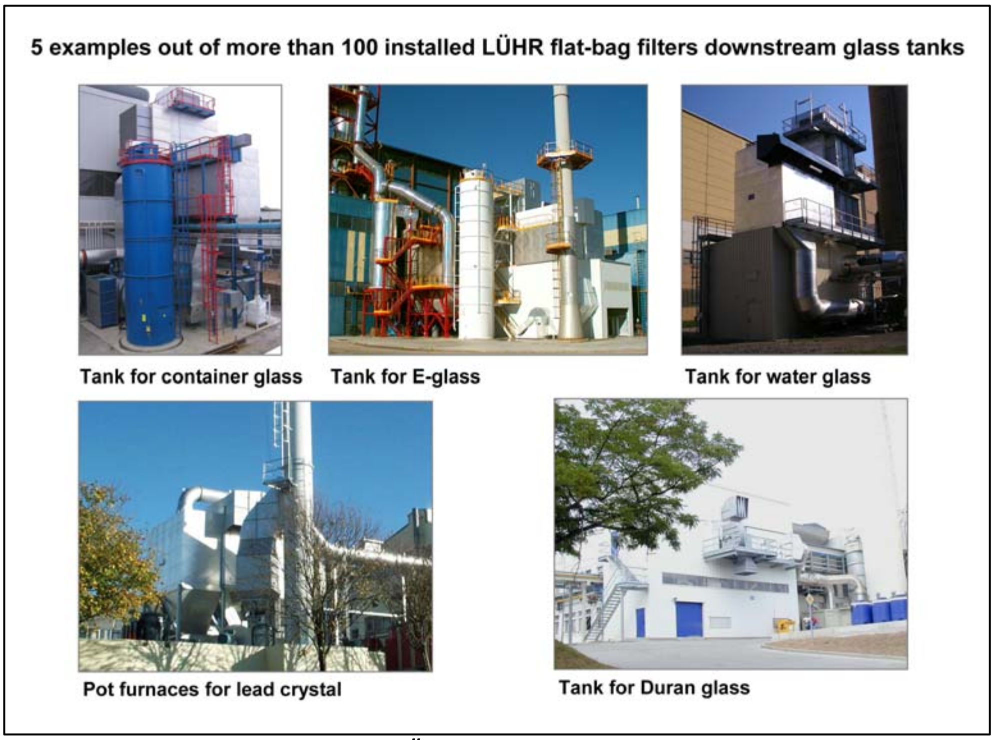
Contents

1 Introduction

This lecture is concerned with the particle and crude gas separation of flue gases extracted from glass tanks by means of fabric filters. The explanations are based on operating experiences gathered by LÜHR FILTER since the mid seventies until today from the installation of more than 100 flat-bag filters downstream glass tanks producing many different products (picture 1).



Pic 1:Application examples for LÜHR flat-bag filters in the glass industry

Modern plants are characterised among other things by:

- reliable observance of the required emission levels in the clean gas:
- particles
- heavy metals (Pb, Se, ...)
- carcinogenic substances (As, Cd, ...)
- gaseous, inorganic substances (HF, HCl, SO_x)
- assurance of the extraction capacity in continuous operation without pressure fluctuations in the tank
- low operating costs, among others
- several years' service lives of the filter fabric
- good additive powder efficiency
- high availability
- low maintenance costs

Pic 2: Tank for special grade class

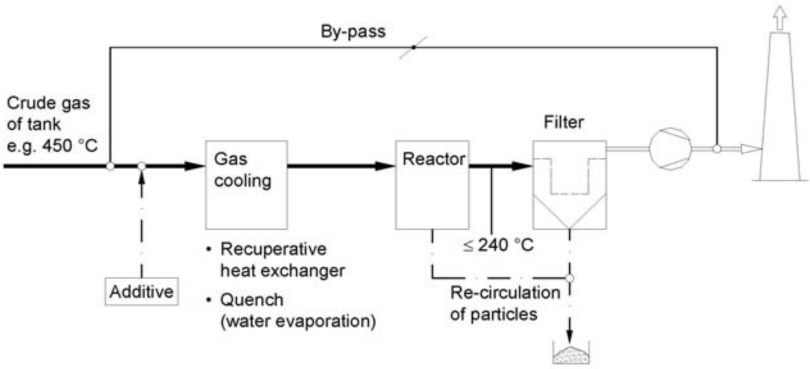
The aforementioned positive operating experiences can only be achieved if the specific features of the application with regard to the process technology as well as the characteristics of the particles to be separated, which differ considerably from many other applications, will be taken into consideration. This lecture states the relevant aspects to be considered when designing fabric filters downstream glass tanks.

2 Process structure and description of components

2.1 Basic process structure

The basic structure of a flue gas cleaning system downstream glass tank is shown in picture 3.

Glass tank for moulded and hollow glass



Pic 3: Basic structure of a flue gas cleaning plant with fabric filter downstream glass tank

Fabric filters are working at flue gas temperatures up to max. 240°C. Therefore it will often be necessary to install a cooling stage upstream fabric filter. The additive powder injection serves – as far as necessary – for the separation of acid crude gas components (HF, HCl, SO_x) and for the corrosion protection.

The individual components are described in the following:

2.2 Flue gas cooling

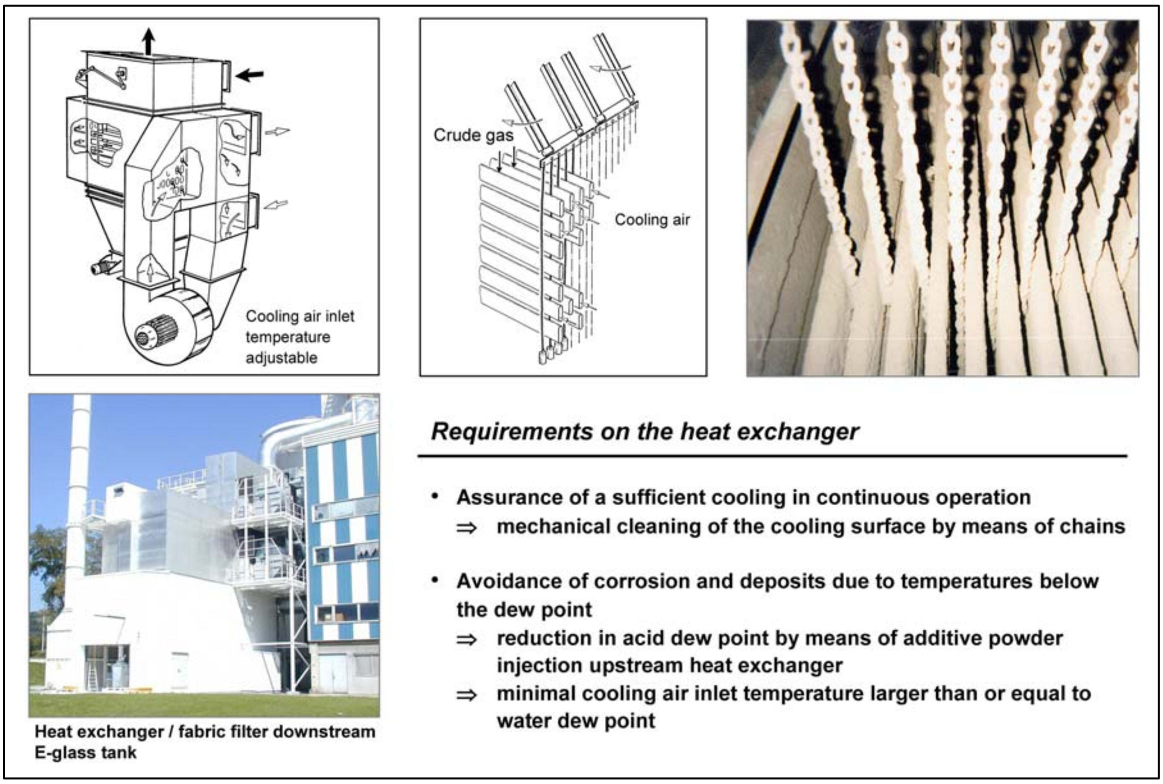
In principle two proven variants for the flue gas cooling are available:

- recuperative heat exchange
- evaporative cooler (quench)

2.2.1 Recuperative heat exchange

Picture 4 shows a schematic view of a gas / air heat exchanger. The cooling is effected by means of indirect heat exchange between the gas to be cooled and the ambient air taken in near the cooler. The flue gas to be cooled flows downwards and upwards between the horizontally located flat sided cooling tubes. A part of the heat

is transferred through the external wall of the flat tubes to the cooling air flowing through the inside of the flat tubes.
The re-circulation of a proportion of the cooling air and the possible additional additive powder injection into the flue gas flow prevent that the temperature near the external walls of cooling tubes from falling below the water or acid dew point.



Pic 4: Recuperative heat exchanger exemplary shown by means of LÜHR flat-tube heat exchanger

Corrosion and particle deposits will be avoided. This aspect gains special importance in case of using fuel burners (higher crude gas concentration and higher dew point) or if the flue gas e.g. has to be cooled down to temperatures < 100°C for the separation of heavy metals.

In general the service life of flat-tubes is well above 5 years.

Due to the strongly adhesive character of the particles existing in the gas flow downstream glass tanks, an automatically working cleaning device has to be installed. Chains are moving slowly to and fro the cooling tube rows, thus serving for the limitation of particle layer on the cooling tubes.

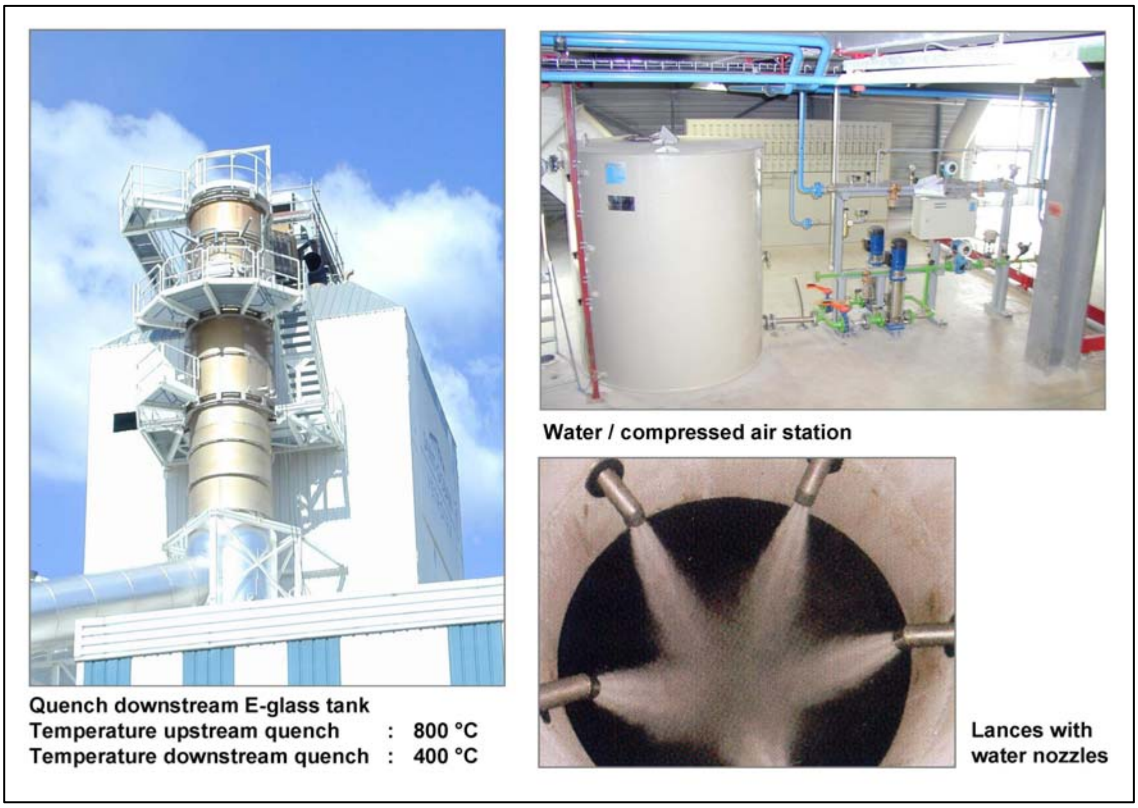
The integration of a heat recovery will e.g. be possible in form of a hot water generator.

2.2.2 Evaporative cooler

During the evaporative cooling, droplets of a fluid are dispersed over the flue gas flow by means of a spraying device, thus extracting heat from the flue gas to be cooled (picture 5). A safe operating mode of the cooler requires the complete evaporation of the droplets at low temperature fluctuations at the cooler outlet. Important aspects for the reliable design of evaporative cooler are:

- procedure of spraying
- guidance of flue gas flow
- control technique

In most of the cases two-media nozzles (water and compressed air) are used for the spraying.



Pic 5: Flue gas cooling by means of water evaporation (Quench)

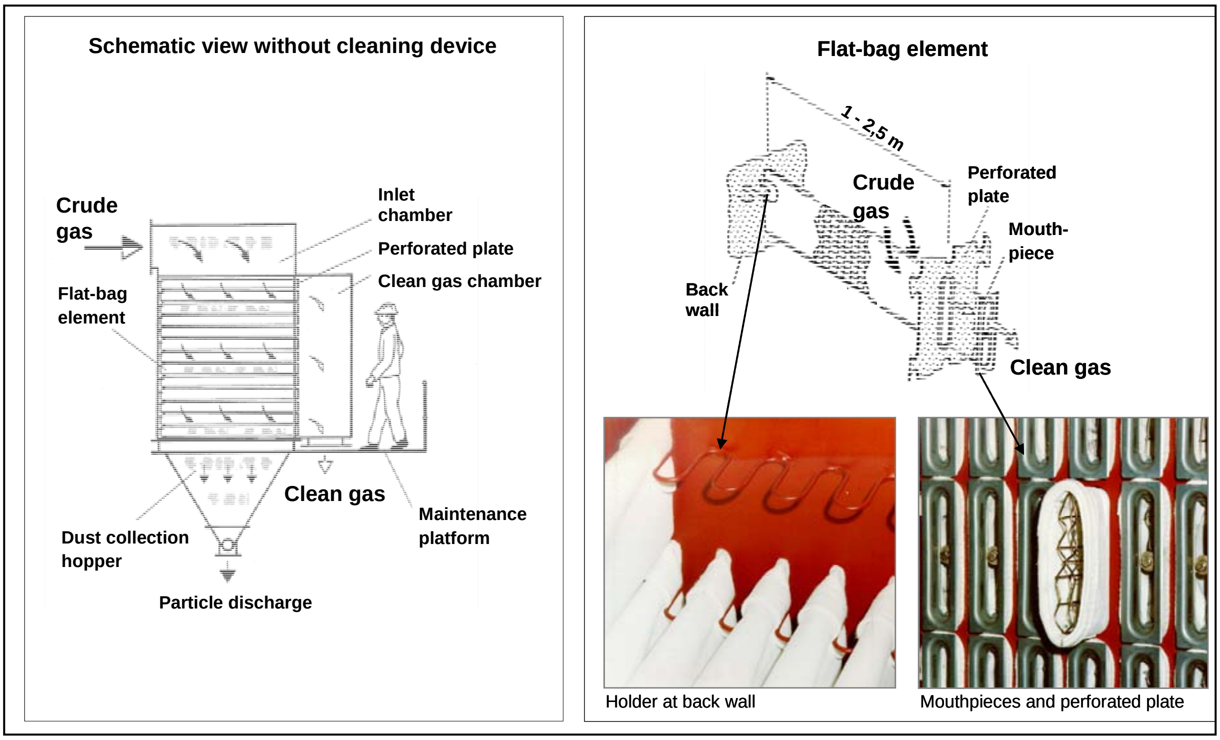
2.3 Fabric filter

2.3.1 Basic design exemplary shown by means of a LÜHR flat-bag filter

The basic design of a fabric filter is shown in picture 6, representing a LÜHR flat-bag filter with horizontally installed filter elements. The filter housing is divided into a crude gas and a clean gas chamber by means of perforated plates.

The filter elements are horizontally installed flat-bags, mounted on support cages. The filter elements are inserted into the filter housing from the clean gas side. They are held in fixed positions in the filter housing, fitted precisely in the holes in the perforated plate, secured without the use of screws thus providing a perfect seal against dust leaks. The gas flow passes the textile filter fabric from the outside to the inside, the particles being retained on the outer surface of the filter elements.

Various methods of on– and off–line cleaning systems with compressed air are mainly used to remove the particles from the filter elements. A detailed description of these filter cleaning devices is not subject this lecture.



Pic 6: Fabric filter exemplary shown by means of LÜHR flat-bag-filter

2.3.2 Filter fabrics

The basic structure of the needle felts used as filter fabric is shown in picture 7. It consist of a support scrim with a fibre batt. A large number of different needle felt qualities is available. Picture 8 shows a table with the qualities of materials predominately used for filters downstream glass tanks and informs about the needle felt purchase costs as well as the admissible operating temperatures.

The selection of a filter fabric and by this the setting of the flue gas temperature within the filter is subject to the requirements of the corresponding application. The selection is influenced among others by:

- crude gas composition
- separation of heavy metals
- separation of acid crude gas components
- acid and water dew point
- investment and operating costs

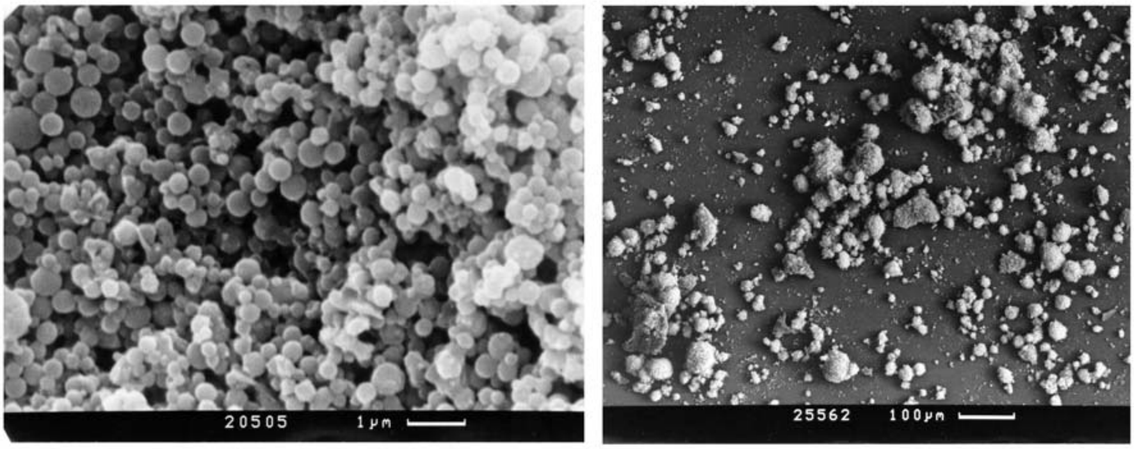
The service lives of the filter bags installed in fabric filters downstream glass tanks total to at least two and well above five years. Conditions for this are:

- Selection of a filter construction with careful treatment of the filter fabric
- Influencing factors:
    - gas inlet to the filter elements
    - cleaning system
    - geometry of support cage
- Reliable observance of the admissible filter fabric temperature in continuous operation
- Selection of a filter fabric in accordance with the corresponding application and with regard to the chemical stress
- If necessary, injection of neutralising additive powders

3 Particle re-circulation

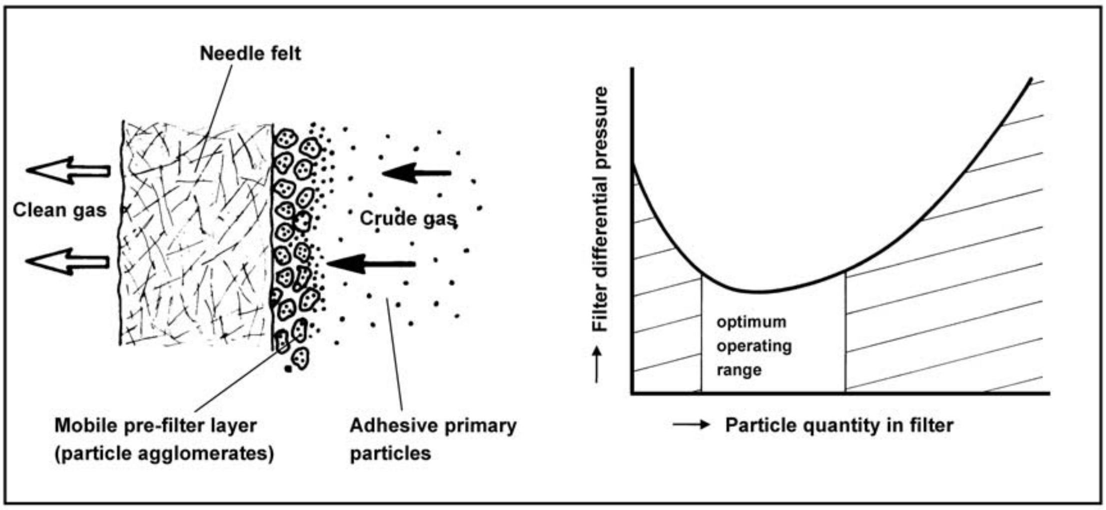
3.1 Particle features

The particles existing in the flue gases of glass tanks are adhesive and extremely fine (particle size about 1 µm or even smaller). Picture 10 shows the fineness of such particles and at the same time their tendency to agglomeration. Fabric filters are able to separate such particles, arisen from re-sublimation from the gas phase and due to their tendency to adhesiveness and agglomeration, with exceptionally high degrees of separation. However, in spite of the low crude gas particle contents of < 1 g/m³, the removal of the separated particles from the filter fabric proves to be difficult. The adhesive forces of the particles which adhere to the fibres of the filter fabric are at least for some time (frequently several hours) definitely stronger than the forces that can be generated by means of up-to-date filter cleaning devices. This leads to undesired high flow resistances and/or forces to the installation of large filter surfaces. The necessary frequent cleaning procedures will increase the energy consumption and reduce the filter fabric service life.



Pic 10: Microscopic photos of adhesive particles

The behaviour in continuous operation of fabric filters for such type of application can definitely be improved by advantageous manipulation of the adhesive forces of the particles to be removed. This will be achieved by means of a multiple particle re-circulation with quantity control (picture 11). The ratio of primary particles to re-circulated particles is approx. 1:50.

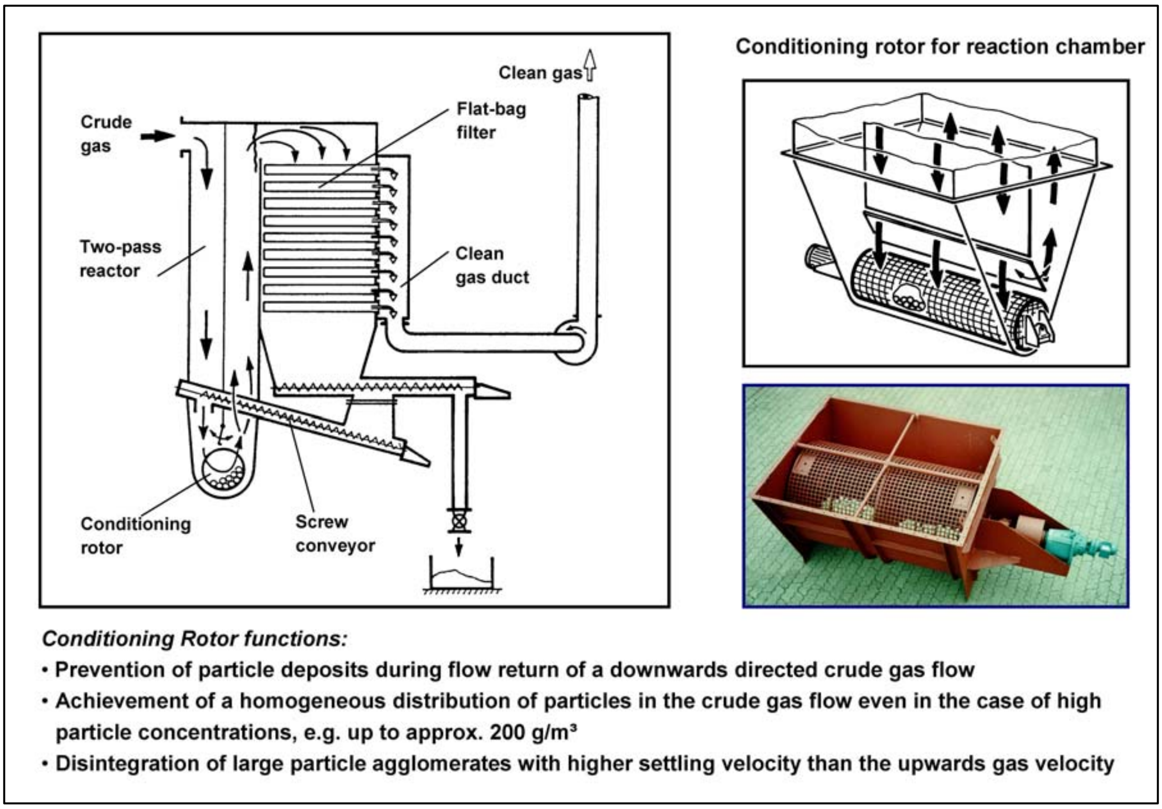


Pic 11: Mobile pre-filter layer fort h eseparation of fine adhesive particles

The agglomerates formed by the re-circulated particles accumulate on the filter fabric. The adhesive primary particles are separated at this mobile pre-filter layer. As the adhesive forces of the agglomerates formed by the older particles are weaker, the agglomerates can be removed very easily from the filter fabric by means of the filter cleaning device.

3.2 Conditioning Rotor – Recycle Process

The reliable realisation of the re-circulation of the particles separated in the filter back into the flue gas flow upstream filter by means of the Conditioning Rotor – Re-cycle Process proved to be successful for many applications (picture 12).



Pic 12: Conditioning Rotor – Recycle Process

The conditioning rotor is a hollow cylinder, manufacturer of a perforated plate with openings of approx. 30 x 30 mm. Up to 10% of its volume is filled with heat- and wear-resistant ceramic balls. The rotor is continuously driven by means of a geared motor with a speed of rotation of approx. 1 rpm. The rotation causes the balls to move relative to each other and to the perforated wall. The flue gas flow passes the rotor axis at first in downward and then in upward direction.

The main functions of a conditioning rotor are:

- prevention of particle deposits when redirecting the particle-laden crude gas flow
- achievement of a homogeneous distribution of particles in the crude gas flow even in case of high particle concentrations, e.g. up to 50 g/m^3
- disintegration of big particle agglomerates

Prior to their discharge, the particles separated in the filter are frequently reintroduced into the reactor by means of a screw conveyor. The particle re-circulation rate is adjustable and can, if applicable, be controlled, e.g. subject to the current crude gas quantity.

Compared to alternative equipment, e.g. pneumatically working re-circulation systems, the Conditioning Rotor - Recycle Process offers among others the following advantages:

- mechanical particle transport by means of reliable screw conveyors
- discharge or possibly intermediate storage of the recycled particulate is not necessary
- homogeneous distribution of the reintroduced recycled particulate into the crude gas flow
- no increase in the O_2 content in the flue gas due to conveying air inlet

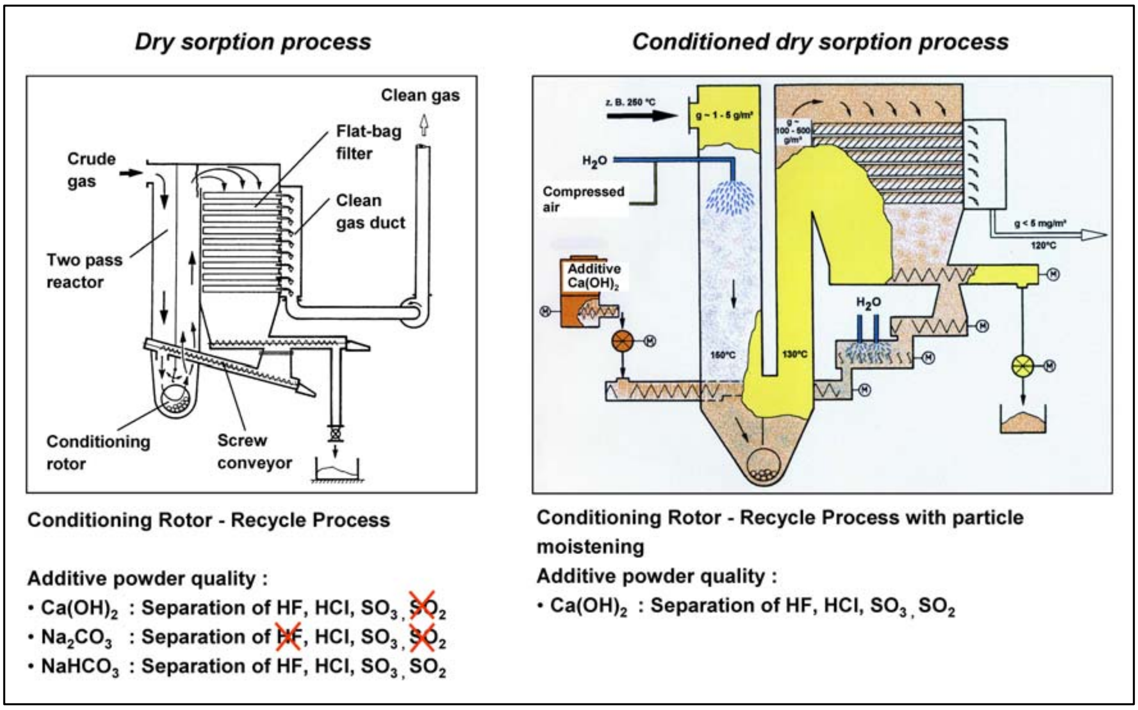
Picture 13 clearly shows the individual components of a filtration plant downstream container glass tank.

Installation during assembly

Pic 13: Applcation example Fabric filter downstream trank for container glass

4 Crude gas sorption

Besides the achievement of low clean gas / residual particle contents, fabric filters also offer the reliable observance of the required clean gas values with regard to acid crude gas components with acceptable use additive powder consumption rates in continuous operation. The additive powder qualities to be used are either $Ca(OH)_2$, $NaCO_3$ or $NaHCO_3$ (picture 14).



Pic 14: Crude gas sorption

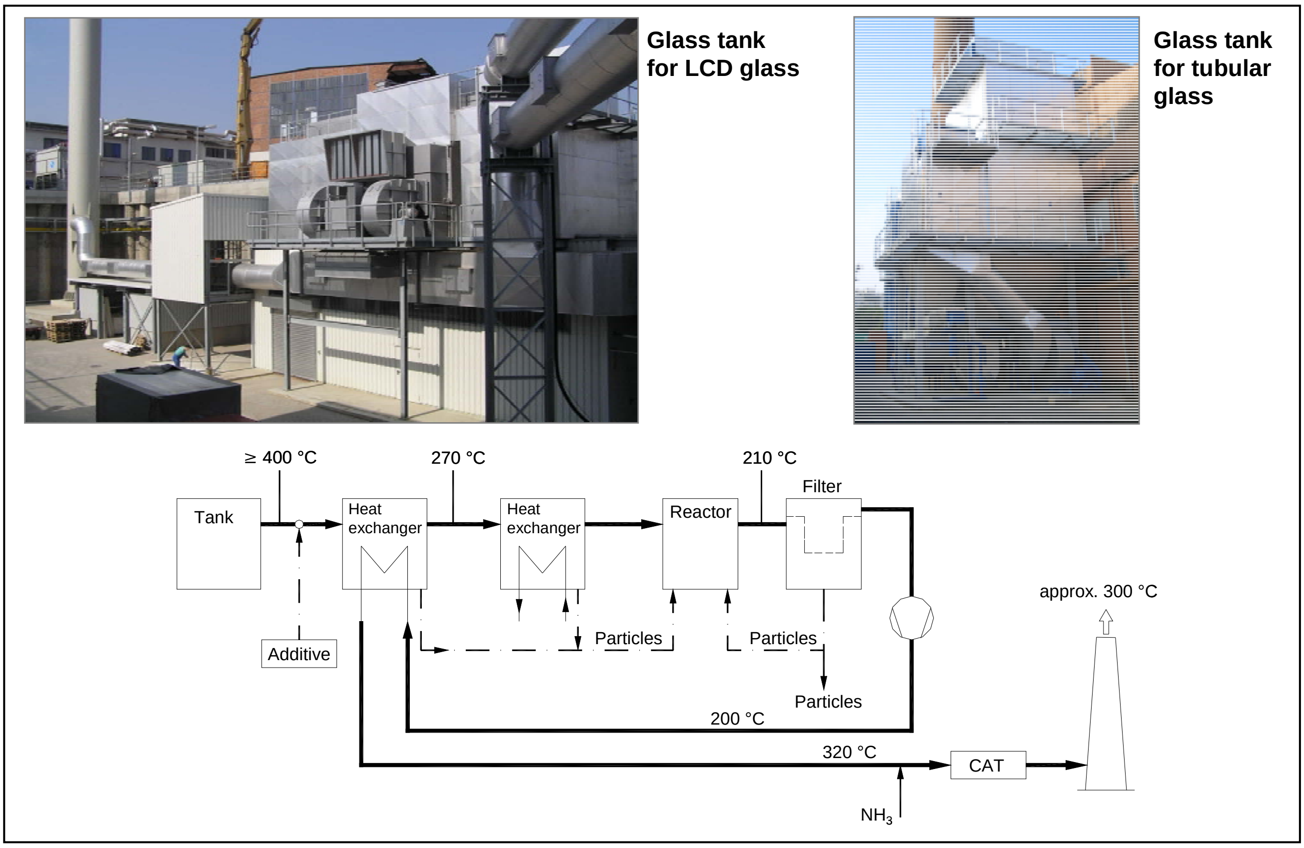
A multiple recycle of the partly saturated additive powder particles, e.g. by using the Conditioning Rotor – Recycle Process, has a positive effect on the additive powder efficiency.
Dry sorption procedures are exclusively used for the separation of HF and HCl. When separating SO_2 with $Ca(OH)_2$ even conditioned dry processes (picture 14 - right hand view) are successfully used downstream glass tanks.

The additive powder quality to be injected and the process variant are selected in accordance with the application in question and the following aspects:

- components to be separated
- degree of separation
- re-circulation of the separated particles into the glass batch
- investment and operating costs

5 Combination of fabric filter with catalyst

Catalysts for the re-sorption of NO_x have to be driven at a temperature > 320°C. When combining a fabric filter with a NO_x catalyst, it will be necessary to reheat the flue gas downstream filter. In those cases it will be advisable to reuse the flue gas cleaned in the filter as cooling gas. A corresponding process scheme is shown in picture 15. If the flue gas temperature upstream heat exchanger does not fall below 400°C in continuous operation, a reheating of the clean gas to approx. 320°C can be achieved with an acceptable expenditure of investment cost.
The low residual particle content in the clean gas downstream fabric filter has an advantageous effect on the behaviour of the catalyst in continuous operation.



Pic 15: Combination of fabric filter with catalyst for the reduction of NO_x (SCR)

6 Summary

Fabric filters with particle re-circulation are used for the flue gas cleaning downstream glass tanks.

- All requested emission limit values concerning particles, heavy metals and acid crude gas components can reliably be maintained in continuous operation.
- They can be used for different types of tanks and glass qualities.
- The correct dimensioning and construction of the plant allows several years' service lives of the filter fabric with a high level of availability.

This lecture did not deal with the details concerning the heat exchanger and filter construction. When selecting a supplier, the different types of construction have to be considered carefully in order to achieve the pre-mentioned positive operating experience even in case of new fields of use.

Depending on the individual case it has to be evaluated by means of the following

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