LUEHR FILTER

Air Pollution Control Technology

SORPTION PROCESSES

FOR THE SEPARATION OF GASEOUS SUBSTANCES

LUEHR FILTER GMBH & CO. KG ...

Chemisorption

Adsorption

Chemisorption and adsorption

LUEHR FILTER GmbH & Co. KG has gained extensive experience in the separation of gaseous components from industrial process off-gases; as evidenced by four large number of worldwide installations. Our reference plants include the following applications:

- dry or semi-dry chemisorption of acid crude gases such as HF, HCl, SO_x, B_2O_3 with Ca- or Na-based additive powders
- adsorption of PCDD / PCDF, as well as Hg and Hg-compounds, by means of activated coal / -coke or other additive qualities with large inner surfaces
- ab- / adsorption of additional gaseous heavy metal compounds

Adsorption in suspended phase

For most of the applications, the adsorption in suspended phase is used for the solution of the corresponding task. One or more adsorbent agents are injected in powder form into the gas flow upstream of the fabric filter and:

- convert the gaseous pollutants in solid matter by chemical reaction (absorption) and / or
- attach the gaseous pollutants to the inner surface of the additive particles (adsorption)

The separation of pollutant-laden particles takes place in the fabric filter.

To allow the reliable observance of requested emission limit values during continuous operation, while at the same time minimising additive powder consumption, it is often useful to adapt the basic variant to the individual application in question by installation of additional units and component parts. The repeated recirculation of additive powder and reaction particles that were separated in the filter, into a reactor upstream of the filter, leads to a clear improvement of separation efficiency, and / or to a reduction in the additive powder injection quantity:

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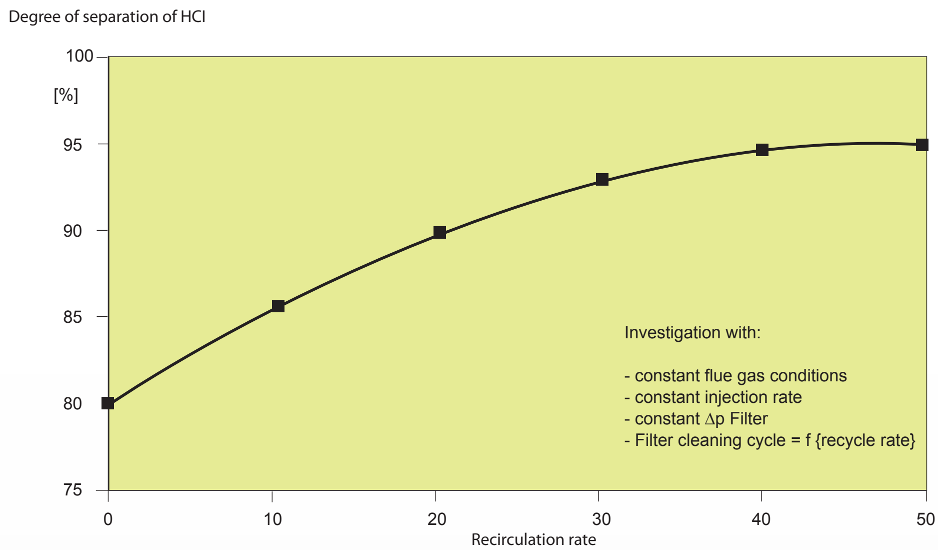
... MORE THAN 45 YEARS OF PRACTICAL EXPERIENCES REGARDING THE CONSTRUCTION OF PLANTS FOR THE SEPARATION OF GASEOUS COMPONENTS

- **Increase in residence time of additive particles in the system.**
- **Higher additive particle density in the reactor upstream filter** (reaction time inside reactor up to >2 sec.)**.**
- **Achievement of a frequent, spatial reorientation of the recirculated particulate with redeposition of the filter cake on the filter fabric.**



The above graph shows the influence of the particle recycle rate on the separation efficiency. It is clearly visible that a recycle rate up to 50-fold will be necessary to achieve optimum additive powder efficiency. In case of an additive powder injection quantity of, e.g. 100 kg/h, the resulting recirculation quantity totals to 5,000 kg/h, corresponding to a volume flow rate of >10 m^3/h.

Fixed bed and mobile bed adsorbers

In addition to the entrainment process with different design concepts, our scope of supply is completed by **fixed bed and mobile bed adsorbers** serving for the separation of gaseous pollutants, while the crude gas is passing a bed of coarse grain absorbent material.

Chemisorption and adsorption

Chemisorption

Fixed bed adsorber

CONDITIONING ROTOR – RECYCLE PROCESS

Non-ferrous metal industry

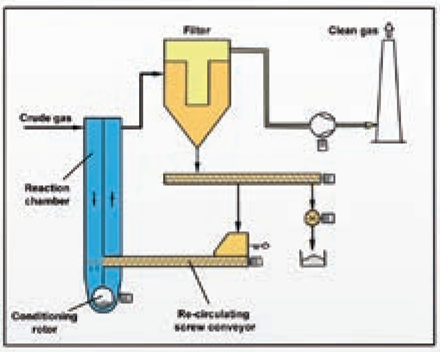
Waste to energy

The **Conditioning Rotor – Recycle Process** developed by LUEHR FILTER allows the reliable recirculation of large particle quantities, even if high concentrations of problematic components such as $CaCl_2$ are part of the particle spectrum. A largely homogeneous distribution of recirculated particles in the gas flow is achieved. Pneumatic conveying systems, which are prone to frequent breakdown, are not necessary.

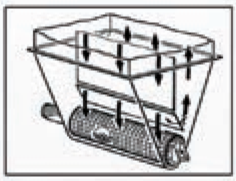
Description of conditioning rotor
The rotor is a hollow cylinder made of a perforated plate with openings of approx. 30 x 30 mm. Up to 10 % of its volume is filled with balls made of heat and wear resistant ceramics. The rotor is continuously rotating at approx. 1 rpm by means of a geared motor. The rotation causes the balls to move relatively to each other inside of the cylinder and to the perforated shell. The rotor is passed through by the flue gas around its axis of rotation at first in a downward, and then in an upward direction.

The main functions of the conditioning rotor are:

- Avoidance of particle deposits when reversing a particle-laden gas flow
- Achievement of an even distribution of particles in the gas flow, even in the case of high particle loads (e.g. up to n x 100 g/m^3)
- Disintegration of large particle agglomerates with a higher settling velocity than the gas velocity in the ascending part of reactor



Conditioning rotor for reaction chamber



Conditioning Rotor – Recycle Process
Prior to being discharged from the filter, the particles separated in the filter are repeatedly reintroduced into the reactor by means of a conveying screw. The particle recycle rate can be adjusted and controlled, if needed, e.g. subject to the current volume flow. Compared to alternative systems, i.e. pneumatically working re-circulation systems, the Conditioning Rotor – Recycle Process offers advantageous features. These are, among other things:

- Mechanical particle transport by means of reliable screw conveyors.
- Discharge and intermediate storage of the recycled particulate prior to a new introduction into the reactor is not necessary.
- Securing of a homogeneous distribution of recycled particulate during injection in the gas flow by using the conditioning rotor.
- No increase in O_2 content in the flue gas due to the intake of conveying air.

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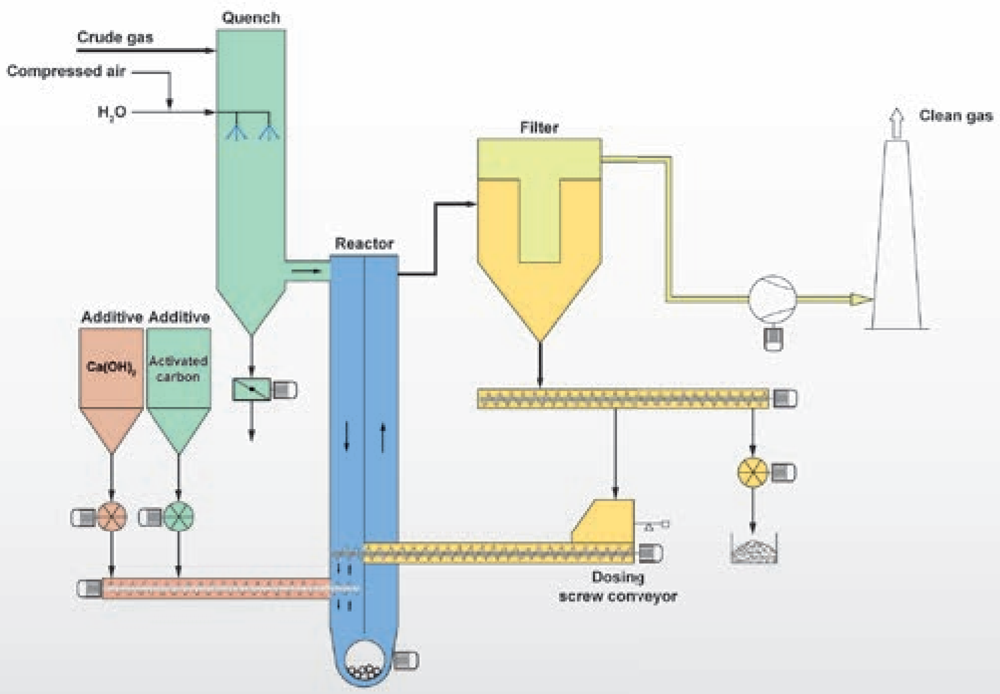
CONDITIONING ROTOR – RECYCLE PROCESS WITH GAS CONDITIONING

The following sequence of reaction results when using Ca-based additive powders at the customary temperature range for fabric filters 100 °C - 220 °C:

SO_3 > HF >> HCl >>> SO_2

The dry temperature, as well as the absolute and relative humidity, has a decisive influence on the HCl and SO_2-separation; however, the separation of SO_3 and HF does not present any problem within the stated temperature range. In order to save additive powder, it will often be useful to cool down the crude gas temperature upstream of the reactor to optimal operating temperatures by means of recuperative heat exchange or, preferably, by using an evaporative cooler. The minimum admissible operating temperature has to be chosen in a way that adhesion and blockages, particularly due to the hygroscopic characteristics of the $CaCl_2$ particles in the plant, will be avoided.

The separation of PCDD / PCDF and Hg is positively influenced by the temperature reduction.




Non-ferrous metal industry


Waste to energy


Chemical industry

CONDITIONING ROTOR – RECYCLE PROCESS WITH GAS AND PARTICLE CONDITIONING

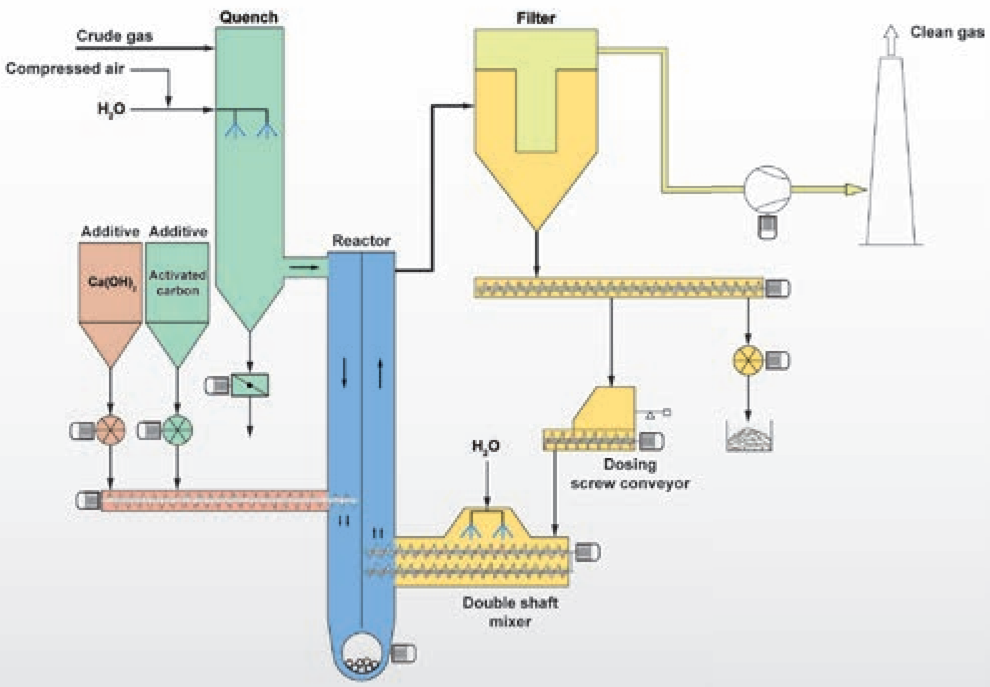
Steel industry

Ceramic industry

Waste to energy

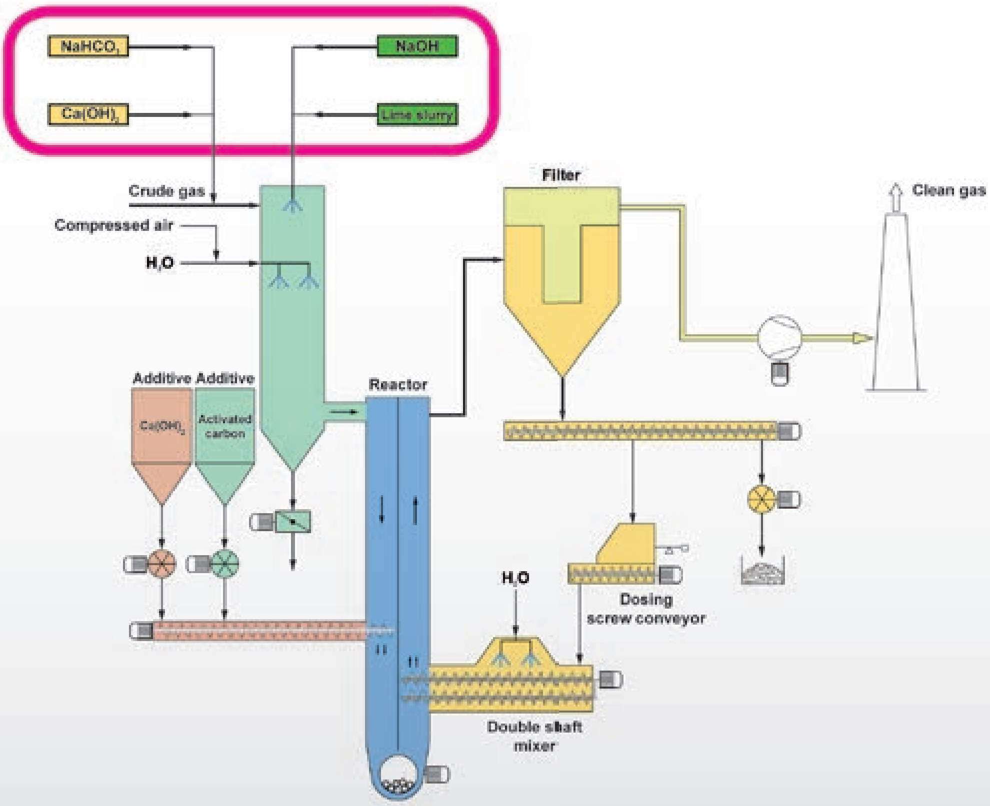
As a result of the increase in the absolute and relative humidity in the flue gas, the gas conditioning has a positive effect on the sorption output. However, good additive powder efficiency, particularly for the separation of SO_2 can only be achieved if the water steam partial pressure close to the recycled particulate lies, at least for a short time, in the range of the saturation steam pressure. This will be achieved by using the chemisorption with particle conditioning. With this type of process, the recycled particulate is wetted prior to being reintroduced into the reactor. The wetting causes an increase in the water steam content at the surface of the additive powder particles, thus improving the reactivity in comparison to the acid crude gas components.

Due to the limited proportional wetting of the recycled particulate, and depending on the gas temperature upstream of the reactor, it might be useful to install an evaporative cooler upstream of the reactor for the adjustment of optimum reaction conditions.



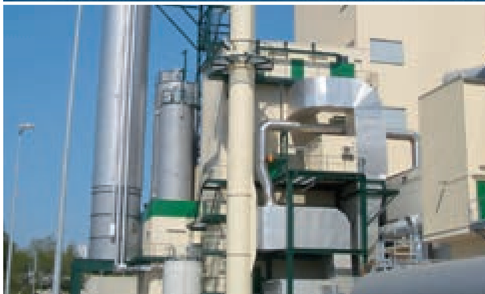
CONDITIONING ROTOR – RECYCLE PROCESS WITH GRADED ADDITIVE POWDER INJECTION

In case of very high pollution gas contents for HCl and SO_2, the stoichiometry of the basic variant of the conditioned dry sorption has partly to be increased definitely above a typical base value of 2 without any additional measures, in order to reliably observe the emission limit values. At rising pollution gas contents it will, therefore, be advisable to apply a graded additive powder injection, thus also using the reaction chamber of evaporative cooler / spray absorber when indicated. The illustration shows some corresponding process variants. With regard to all concepts, the main quantity of additive powder is, in the nominal case, injected into the reactor downstream of the evaporative cooler. The injection of additive powder upstream of, or inside, an evaporative cooler / spray absorber mainly serves as corrosion protection and particularly, in case of pollution, gas peaks for the pre-separation of acid pollution gas components.



RDF to energy

RDF to energy

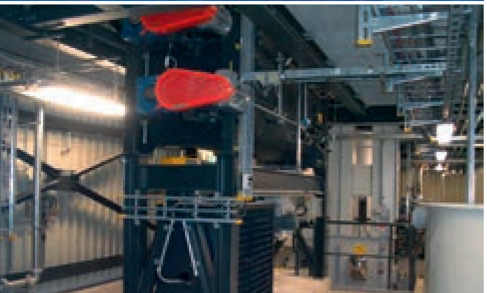


RDF to energy

OPTIMISATION OF OPERATING COSTS BY USING CAO INSTEAD OF $CA(OH)_2$


RDF to energy

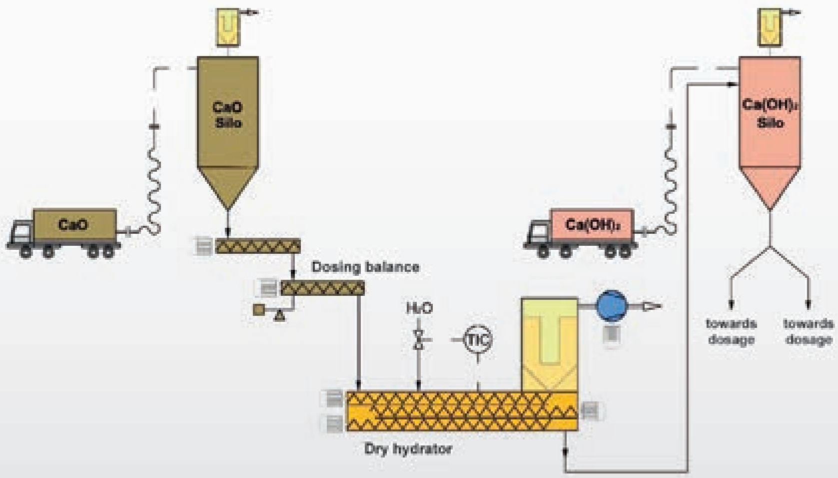

Silo plant

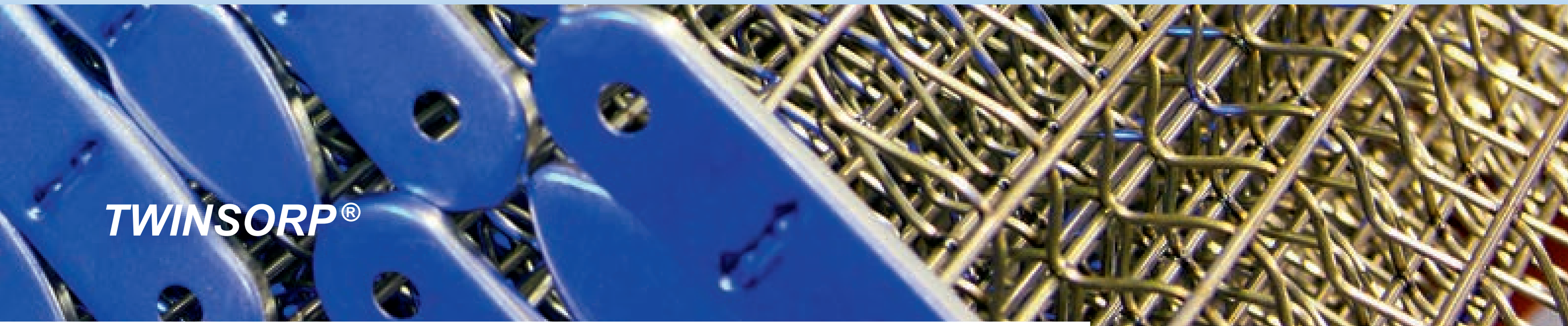

Dry hydrator

In case of the conditioned dry sorption, the Ca-based additive powder is injected into the reactor in the form of $Ca(OH)_2$. Compared to the use of CaO, e.g. for the spray sorption, this results in a disadvantage due to the higher purchase costs for $Ca(OH)_2$. In order to offset this cost disadvantage, plants with higher additive powder consumption are often provided with an additional dry hydrator for CaO. In this case, the additive powder is supplied in the form of CaO. It is converted into $Ca(OH)_2$ by means of H_2O injection in a dry hydrator, it is stored in an intermediate silo, and provided as dry additive powder for the injection into the reactor and/or upstream evaporative cooler. The intermediate silo is adequately dimensioned to allow a direct filling of the silo with $Ca(OH)_2$ in case of maintenance and repair works near the dry hydrator. A corresponding scheme is shown in the illustration below.

Several plants in Europe have been provided with this technology. The illustration shows a plant, realised with a dry hydrator for a $Ca(OH)_2$ production capacity of approx. 3.5 t/h.

As an alternative, there is also the possibility to install the dry hydrator close to the additive powder injection point near the reactor. The produced $Ca(OH)_2$ can now be injected directly into the reactor without temporary storage in a silo. This variant will not be possible in the case of a graded additive powder injection.





TWINSORP®

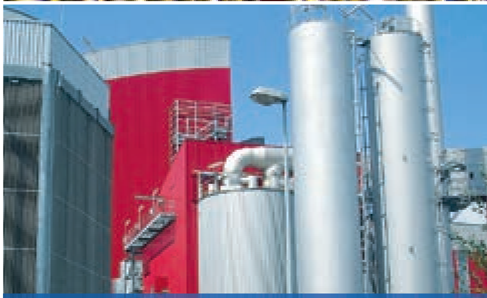
... a simple hybrid process for increased requirements on emission limit values.

The combination SNCR – Conditioned dry sorption – Wet scrubber (TwinSorp®-process) allows the observance of very low emission limit values in an economical way; i.e. for NO_x, NH_3, acid crude gases such as HCl and SO_x, Hg and other heavy metals, and dioxins/furans.

The conditioned dry sorption of this process variant is operated in such a way that the crude gas downstream of this stage will comply with the requirements of, e.g. 17. BImSchV or EU Directive 2000/76/EC, as much as possible. Depending on the application in question, the downstream installed fine cleaning stage serves for the:

- separation of NH_3
- progressing reduction in emission values, e.g. for the acid crude gas components
- heat recovery

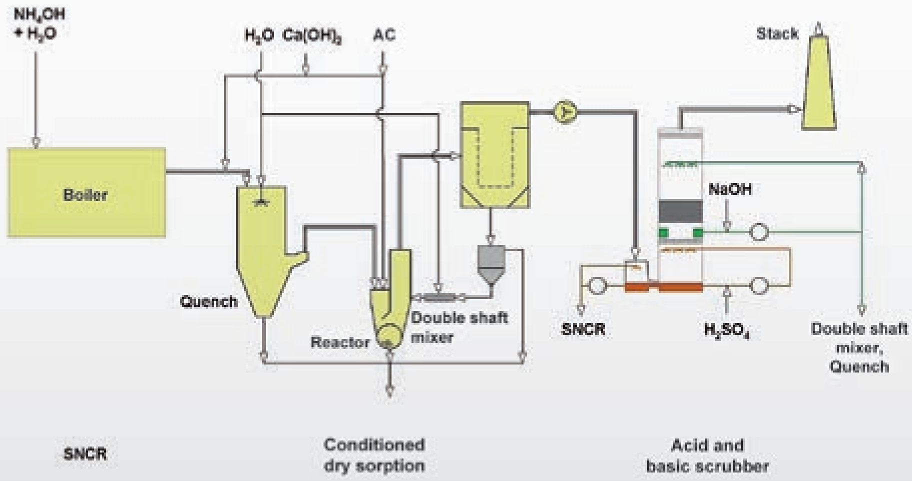
The process works waste water-free.



Biomass to energy

Waste to energy

RDF to energy



DRY SORPTION WITH $NAHCO_3$

RDF to energy

Tyre combustion

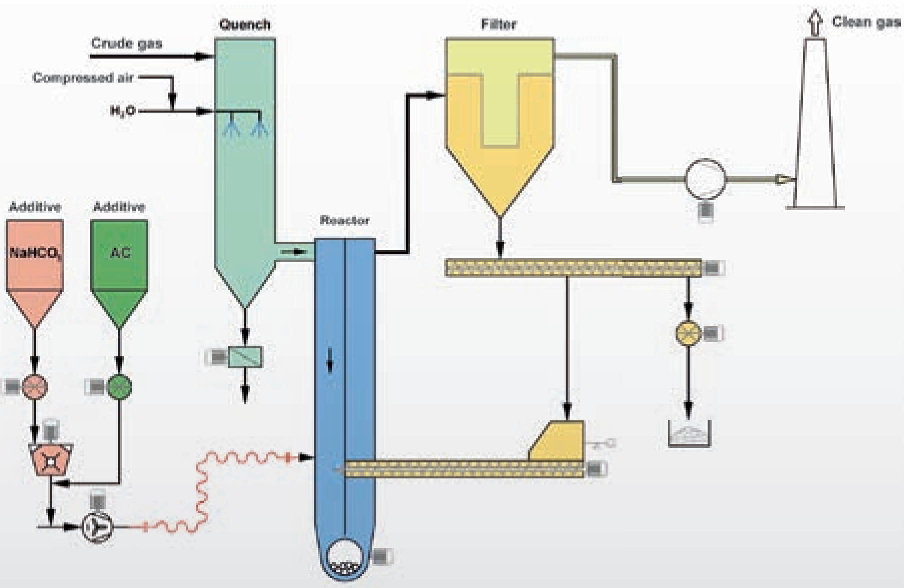
LUEHR FILTER has a comprehensive knowledge regarding the use of the dry sorption process with $NaHCO_3$. For many years, plants have been realised for different applications, i.e.:

- Aluminium secondary melting plants
- Glass tanks
- Tyre combustions
- Domestic waste combustions
- RDF combustions
- Thermolysis for domestic waste
- Biomass combustions (waste wood)

Regarding this process, special attention has to be paid to:

- the selection of an adequate classifier mill for the activation of $NaHCO_3$.
- consistent injection of additive powders into the crude gas duct and/or into the reactor upstream of the filter.

We have conducted comprehensive studies at a domestic waste incinerator for the optimisation of the additive powder efficiency. One of the main results was that multiple particle recirculation helps to achieve a definite im-provement of the additive powder efficiency.



In addition, it may be noted that the evaporative cooler shown in the illustration will only be used if the gas temperature has not been adjusted in an optimal way with regard to the application. For instance, in case of simultaneous separation of PCDD/PCDF, and particularly Hg, the temperature should be limited to max. 180° C.

As far as no particle recirculation has been provided for the optimisation of the additive powder efficiency, the scope injection of additive powder in the ducting, as well as design of reaction line upstream of the filter, will be optimised by using computer simulation programmes.

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FIXED BED ADSORBER AND MOBILE BED ADSORBER

LUEHR fixed bed and mobile bed adsorbers are used for the adsorption of gaseous pollutants such as:

- PCDD/PCDF
- Heavy metals, i.e. mercury
- Hydrocarbon compounds
- Gaseous, inorganic substances, such as HCl, SO_2, H_2S

at grainy activated carbon/-coke or other coarse-grained sorbents.


Fixed bed adsorber


Fixed bed adsorber


Mobile bed adsorber

The excellent separation efficiency allows the reliable observance of extremely low emission limit values for the stated pollutants, even in case of high input concentrations.

Advantageous features of LUEHR fixed bed and mobile bed adsorbers:

- Simple plant technology with low maintenance
- Low investment and operating costs
- Reliable observance of the requested residual concentrations in the clean gas at good utilisation of adsorbing agent; i.e. due to a consistent inlet flow distribution over the complete gravel bed area, and a uniform discharge of adsorbent over the whole adsorber area
- Low pressure loss; i.e. due to uniform flow distribution across the entire bed area
- Depending on the application, selection of a variable bed thickness between approx. 500 and 1,000 mm
- High reliability; i.e. due to a consistent flow across and through the entire adsorber bed material

Sizes

- Volume flows of up to max. 10,000 Am^3/h in one unit
- Volume flows of 10,000 Am^3/h up to approx. 40,000 Am^3/h by parallel arrangement of several single units

Criteria for application

- Particle contents in the gas flow upstream of the adsorber < 5 mg/Nm^3. To ensure that an early, partial replacement of adsorbent material does not become necessary (as a result of an excessive pressure drop, but only after saturation of adsorber material), it might be necessary to install a LUEHR flat-bag filter for the particle separation upstream of a mobile bed adsorber.
- Gas temperatures < 150 °C

Handling of sorbent material

- The replacement of granular sorbent takes place during disconnected admission after saturation of material. The adsorber material is partly, or completely, discharged via collection hopper and manual damper, by means of manual operation of discharge grid. The new material is filled from above out of adequate transport containers (e.g. Big Bag) and evenly distributed over the entire bed area (fixed bed adsorber).
- On request, the partial or complete discharge of saturated material, as well as the filling with new adsorbent, can be automated (mobile bed adsorber).

Find the contact person responsible for your area on www.LUEHR-FILTER.com

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