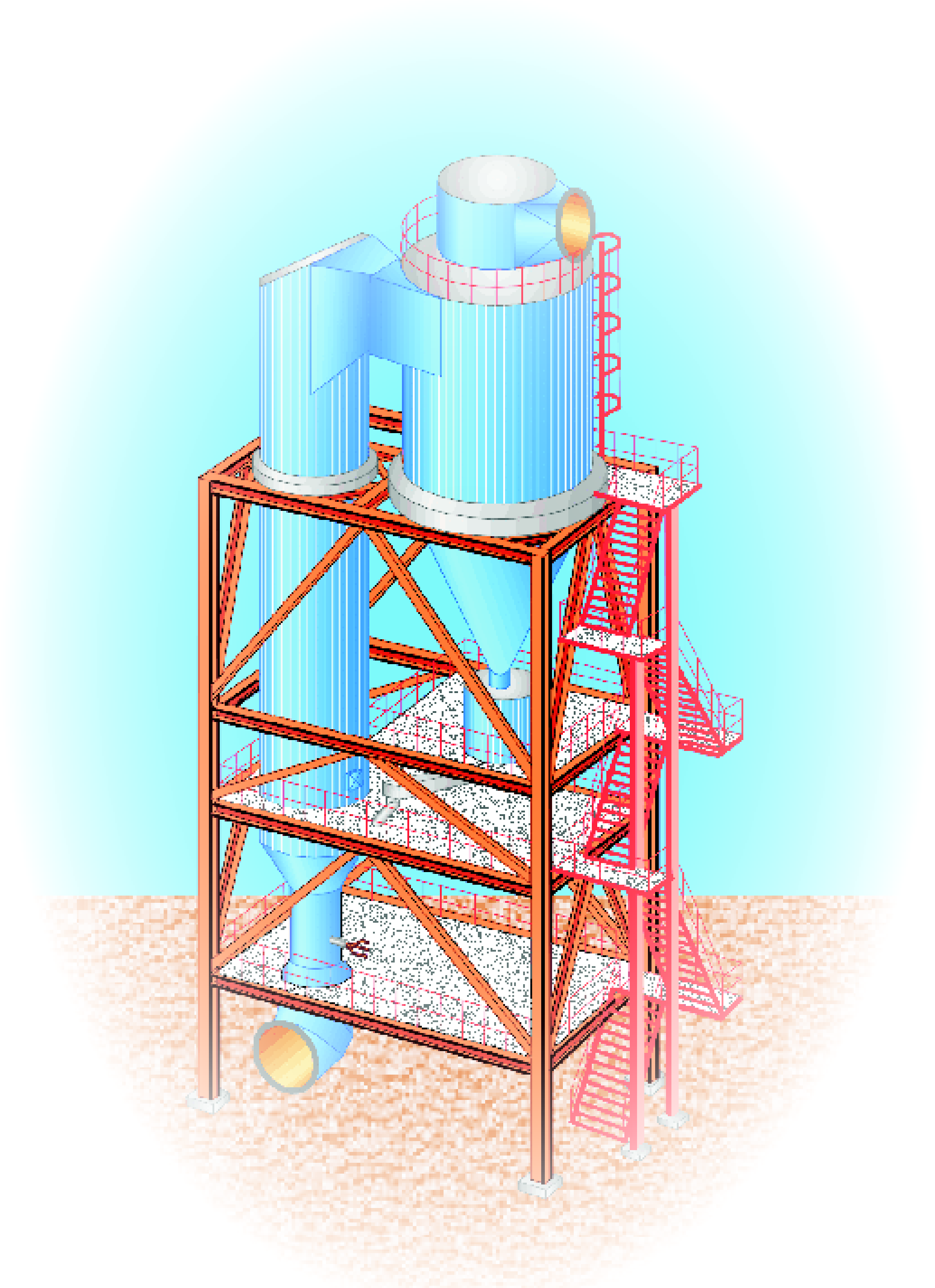
Gas Suspension Absorber



Description

Introduction

KC Cottrell proudly offers our unique Gas Suspension Absorber (GSA) process. The KC Cottrell GSA process means an extremely efficient utilization of the lime reagent, thus reducing requirements for fresh lime to a minimum.

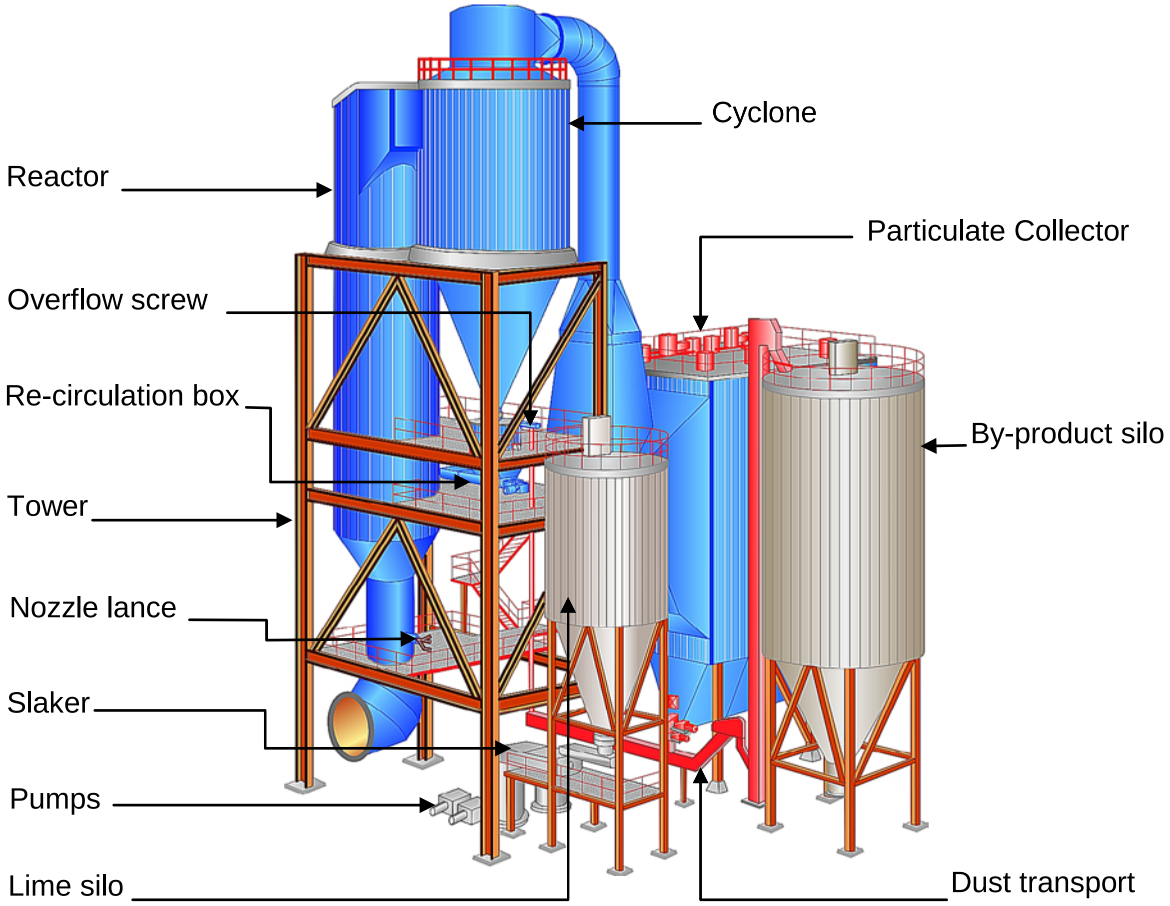
One of the reasons for the high efficiency of the KC Cottrell GSA is that the reactor has been based on gas suspension technology. This means that a very large concentration of fly ash, dust particles and lime builds up inside the reactor. The concentration is normally 50 to 100 times as high as in a conventional reactor.

The effect is further enhanced by the fact that lime, fly ash and by-products are recycled about 100 times in the KC Cottrell GSA system.

A short erection period is achieved due to a modular design, offering enormous flexibility.

Maintenance costs for the KC Cottrell GSA are extremely low compared to more conventional plants. One reason for this is the minimal wear and tear due to few moving parts and a very simple, uncomplicated and stationary nozzle.

With its ability to comply with extremely low emission levels, the KC Cottrell GSA is built for the future.



Example

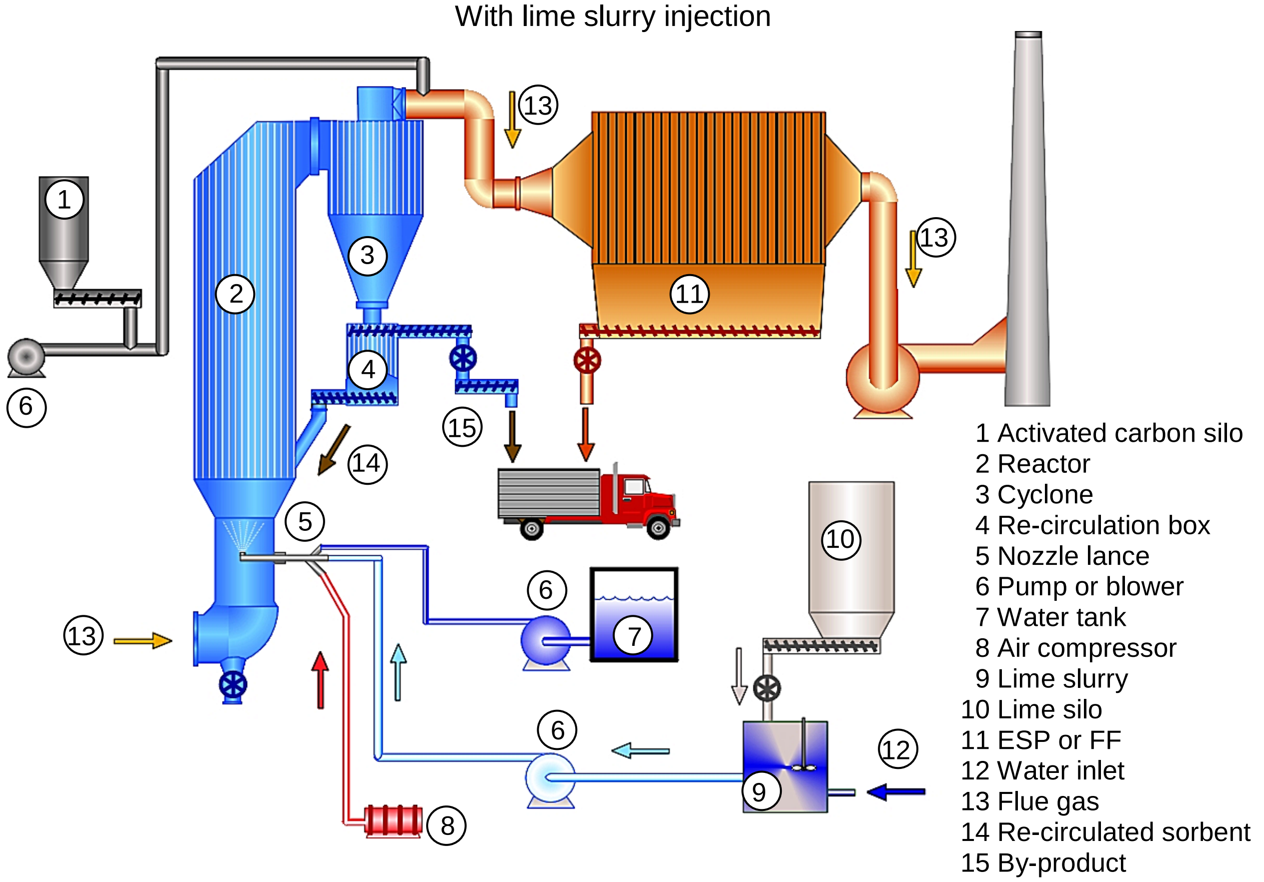
Process description

A standard KC Cottrell GSA flue gas cleaning plant comprises the following main components:

- Flue gas duct system
- Reactor
- Cyclone
- Re-circulation box
- Dust filter
- Lime slurry preparation system
- Activated Carbon system
- By-product system

Reference is made to the flow sheet presented below.

Semi-dry system
With lime slurry injection



Flue gas duct system

The flue gas duct system consists of all ducts required for transporting flue gas from the combustor to the reactor, from the cyclone to the dust filter, from the dust filter to the ID-fan and from the ID-fan to the stack.

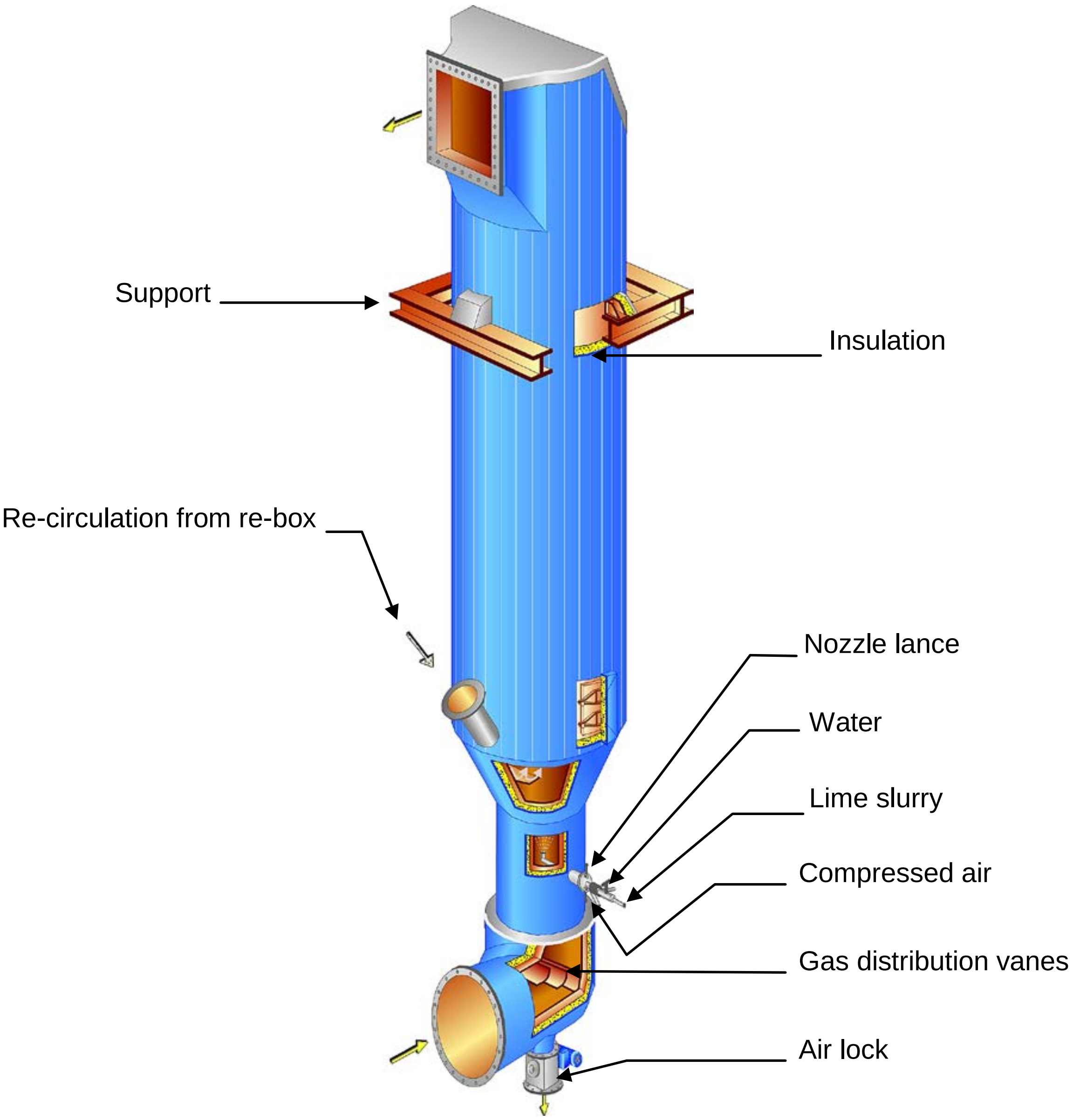
Reactor

The reactor system comprises an inlet bend, a venturi and a riser section as demonstrated in figure 2 below.

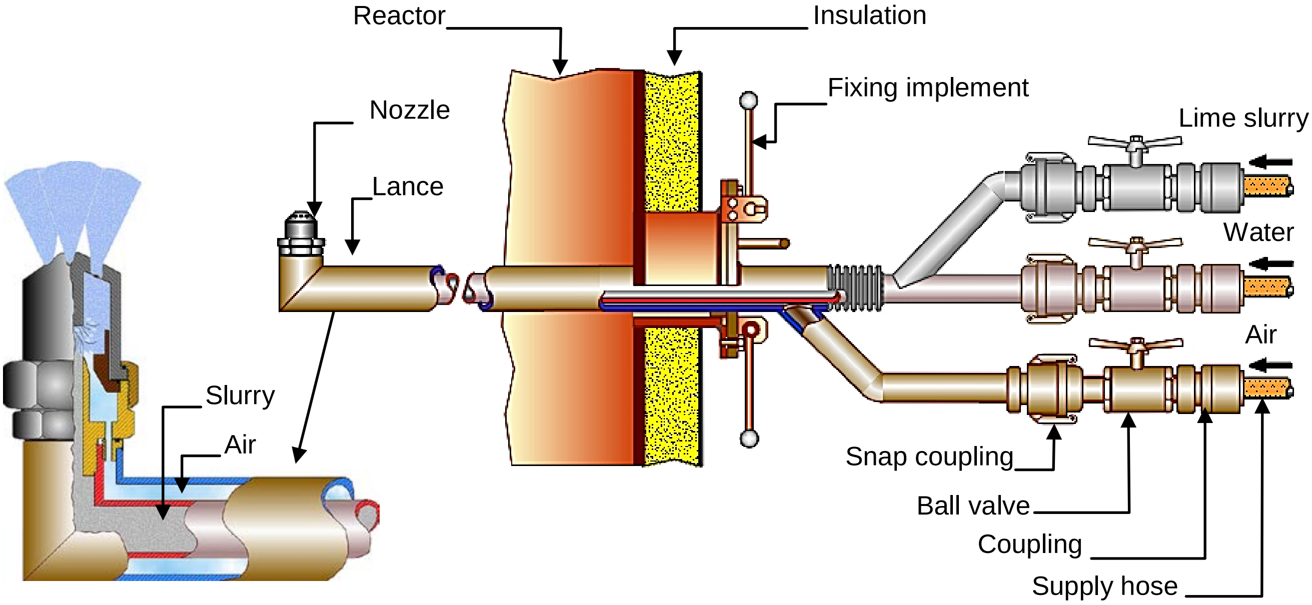
Flue gas is led through the venturi via the inlet bend, and into the reactor. In the reactor the pollutants are removed by chemical reactions with the injected lime.

The only purpose of the inlet bend is to ensure proper distribution of the flue gas in the venturi. This is done by means of guide vanes placed in the bend.

In the venturi the cross section of the duct is narrowed in order to increase the linear flue gas velocity. The increased velocity ensures that solid material can be transported by the flue gas to create a fluidised bed in the riser section.



A dual fluid nozzle is installed in the venturi, and through this nozzle fresh lime slurry and water are dosed into the riser section. The nozzle schematically displayed in below figure, is developed by KC Cottrell and is a pressurised-air atomizing nozzle, very sturdy, hard-wearing, and non-chocking.



The main part of the flue gas treatment takes place in the riser section due to the intimate contact between the lime and the flue gas. In this section the lime reacts with the acid constituents in the flue gases, thus capturing and neutralising them.

Because of the very large reaction surface formed by the fluidised bed, the contact between the lime and the acid constituents in the flue gas is very efficient, and the degree of acid removal correspondingly high.

The chemistry in the riser section leading to elimination of the acid constituents is simplified in the following reactions:

$$2HCl + Ca(OH)_2 = CaCl_2 + 2H_2O$$

$$2HF + Ca(OH)_2 = CaF_2 + 2H_2O$$

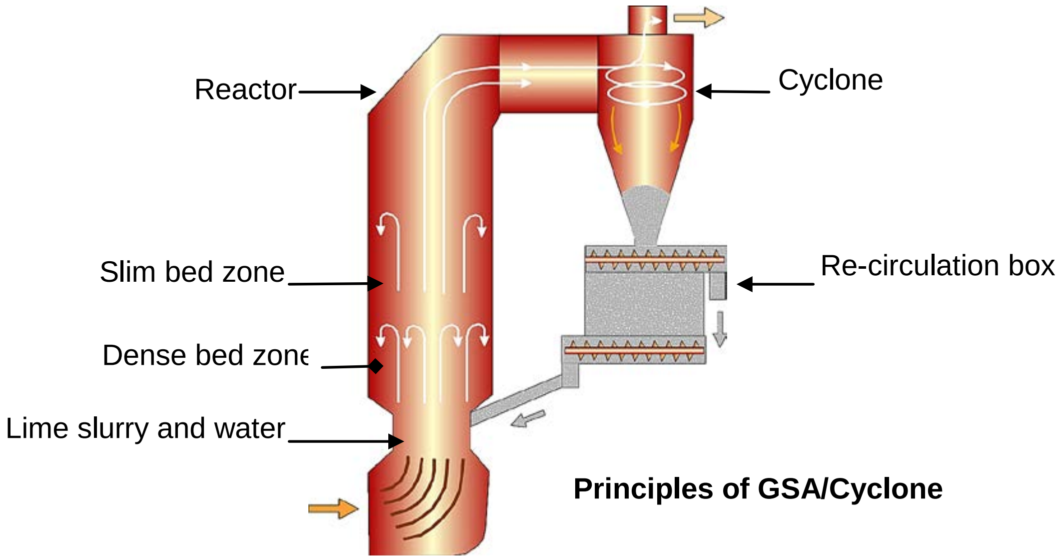
$$SO_2 + Ca(OH)_2 = CaSO_3 + H_2O$$

$$CaSO_3 + \frac{1}{2}O_2 = CaSO_4$$

Additional water injected into the riser section through the nozzle is provided to cool down the flue gas. The main part of the cooling process takes place through evaporation of water from the wetted, recirculated material. The amount of water is adjusted in order to maintain the required temperature in the purified flue gas. This temperature must be as low as possible due to the fact that the ability of the slurry to absorb the acid components in the flue gas is increased at decreasing temperatures. And contrary, a too low temperature will increase the caking tendency of the re-circulated material in the reactor. When compromising between these two tendencies, we find the optimal process temperature.

Cyclone

In the riser section the flue gas velocity is relatively high, and some of the solid particles are transported by the flue gas to the top of the riser section and into the cyclone.

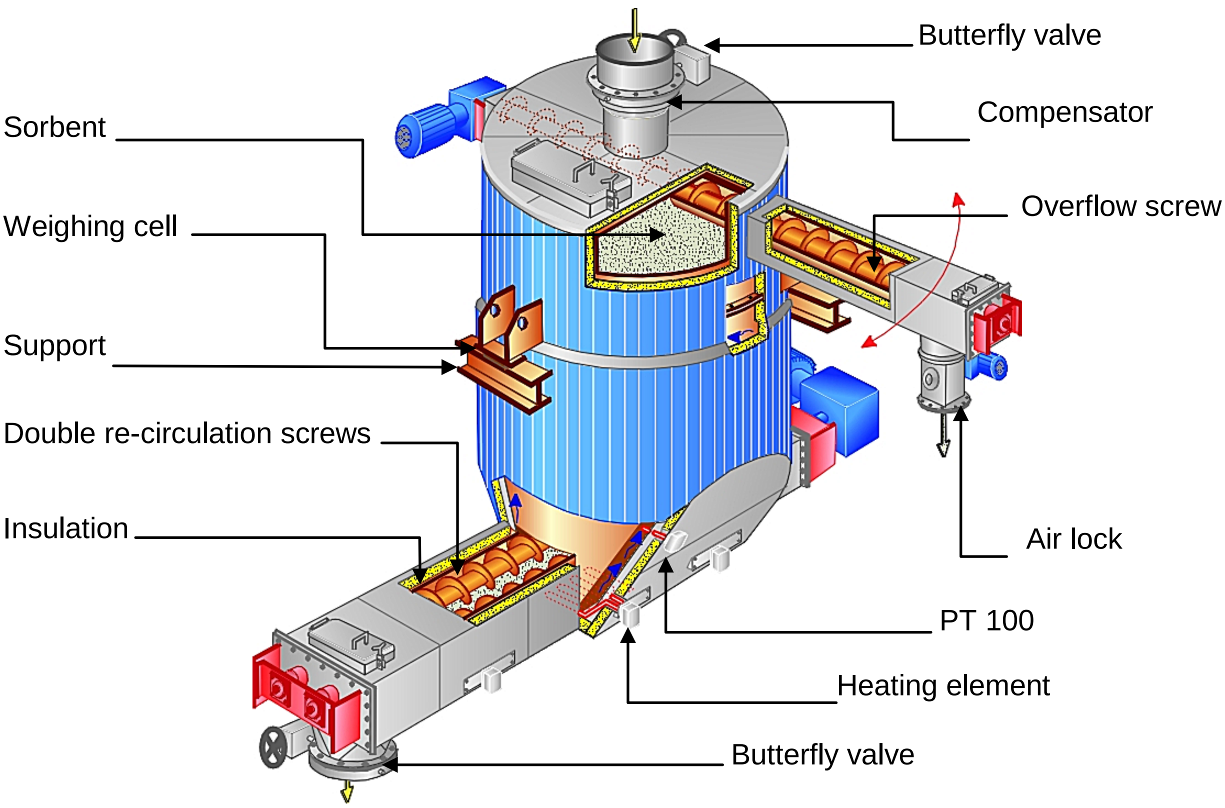


Principles of GSA/Cyclone

In the cyclone the main part of the particles is separated from the flue gas. Approximately 99% are captured, and only the small particles are transported by the flue gas to the filter. The captured particles are returned to the reactor via the recirculation box.

Recirculation box

The purpose of the recirculation box is to have a buffer of reaction products with excess lime to maintain the absorption capacity and for peak temperature control purposes.



The re-circulation box consists of a metal box provided with conveyors. Two screw conveyors are placed at the bottom of the box for transport of solid material back into the riser section, whereas the screw conveyor at the top bleeds out the excess of fly ash and material formed by the chemical reactions.

The bottom screw conveyors are controlled by a frequency converter, whereas the one at the top operates at constant speed.

Activated carbon system

In order to capture mercury, dioxins, and other organic micro pollutants activated, carbon is injected into the flue gas in the duct leading to the dust filter. Mercury and dioxins adsorb to the surface of the carbon and are precipitated in the dust filter.

The dust filter

The solids-containing flue gas is led from the cyclone to a dust filter. The dust filter could be either a fabric filter or an electrostatic precipitator. KC Cottrell supplies both. The dust filter chosen depends on the contents of the flue gas and the cleaning requirements.

ID-fan

The ID-fan is placed between the dust filter and the stack. The ID-fan serves two purposes:

- Maintaining the desired pressure level in the boiler
- Overcoming the pressure drop generated in the ducts, the GSA and the dust filter

Lime preparation (CaO OR $Ca(OH)_2$)

The GSA process works with one of the two absorbents; burned lime (CaO) or hydrated lime ($Ca(OH)_2$).
CaO is frequently preferred over $Ca(OH)_2$ by the client due to a lower purchased cost.
When hydrated lime occasionally is recommended before burned lime, it is due to high inlet acid concentrations combined with low inlet temperature conditions.

CaO lime preparation

When burned lime is applied it is initially made to react with water in order to form hydrated lime slurry in a specially designed slaking unit. The reaction scheme for the slaking process is as follows:

$$CaO + H_2O = Ca(OH)_2 + \text{Heat}$$

The slaking unit comprises two stages. In the first stage the lime is slaked to an approx. 40% suspension, and in the second stage the paste produced in the first stage is diluted to 20% slurry.

During the slaking of the burnt lime, the temperature of the slurry increases to approx. 90-95°C due to the chemical reaction.

From the slaker the lime slurry is transferred to a slurry mixing tank. From the mixing tank lime slurry is dosed into the reactor by means of the dosing pumps.

$Ca(OH)_2$ lime preparation

When hydrated lime is applied no preparation system is called for. The dry lime is simply blown as a dry powder into the venturi part of the reactor from a lime silo.

Operating procedure

Description of the control system

The GSA process is equipped with an automatic control and monitoring system that serves the purpose of ensuring a safe, stable and at the same time an economically optimal operation by continuous control of essential process parameters.

Essential process parameters would be those indicating the state of the entire flue gas treatment plant as well as the state of sub-systems.

All essential process parameters are provided with alarm levels and are continuously monitored by the control system.

If alarms are given, it is an indication of the system being in abnormal operating mode.

The control system comprises several control loops ensuring that cleaning of flue gas is undertaken automatically, and that no action is required on the operator's part.

The main control loops are:

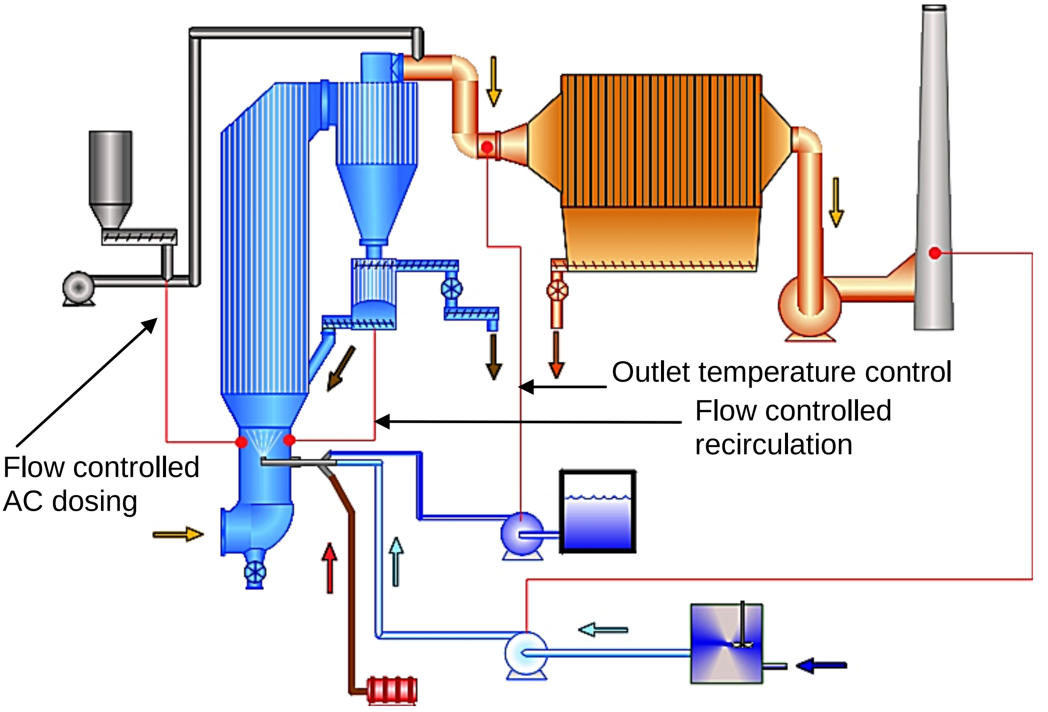
- Flow control of re-circulated media
- GSA outlet gas temperature control
- Lime feed control
- Activated carbon feed control when required.

That also is presented in the figure below.

The automatic control system includes procedures for control of the plant in three essential phases: Start-up, operation and stop. Apart from normal stop there is an emergency stop sequence as well.

If emergency stop is activated, the plant stops immediately without regard for the consequences.

Further, the control system includes procedures for a forced shutdown that will quickly bring the plant back into stable operating conditions.



Flow control of re-circulated media

The amount of re-circulated media is controlled by the flue gas flow through the absorber via a flow-proportional measurement.

Outlet temperature control

The GSA outlet temperature is controlled by the water injected into the GSA venturi.

The speed of the water pump is controlled by a temperature measurement of the outlet gas. It ensures that the flue gas is cooled down to a suitably low temperature - keeping a safety margin to the dew point - in order to minimize the consumption of lime. In addition, the inlet temperature is used partly as feed-forward during start-up.

Lime feed control

Lime slurry addition in the GSA is controlled by measuring the SO_2 and HCl concentrations in the stack. The outlet concentrations are warranty parameters. The measured proportional deviation from the emission set point is used in the control system to calculate the amount of lime or lime slurry to be added in the GSA-system.

An increase in set point will result in a decrease in lime slurry consumption and vice versa.

Flow control of dosing of activated carbon

The control system comprises a simple flow proportional dosing system that controls the injection of activated carbon before the dust filter when required.