

INDUSTRIAL EXHAUST GAS COOLING SYSTEMS FROM SCHEUCH

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The main objective of exhaust gas cooling is the adjustment of gas temperatures to the economically available filter media (defined filter inlet temperature) and the accompanying reduction in the volume of exhaust gas to be cleaned, initially for economic reasons. As the cooling of process gases releases significant amounts of energy, our commitment to environmental awareness requires that we regularly consider options for integrating regenerative methods of waste heat utilization in our concepts. For example: The cooling of 200,000 m³/h of dry air by 100 °C corresponds to a thermal output of approximately 3.4 megawatts [MW].

For selection of the "right" cooling concept and its appropriate sizing the cooling task and general conditions affecting the cooling process need to be defined. The thermal output (Q) that can be dissipated by cooling an exhaust gas stream is calculated according to the formula

$$Q = m \times cp \times \Delta t$$

m...Mass flow V [kg/s]

cp...Specific heat capacity [kJ/kgK]

Δt...Temperature difference [K]

For a quick estimate, the calculation can be made with an assumed constant specific heat capacity of air. However, it should be noted that in the final analysis the gas composition as well as the temperature dependency of the thermal capacities must be considered in order to perform a precise calculation. Water vapor (moisture) and CO₂ in the exhaust gas can to some extent substantially increase the need for cooling. In addition, fluctuations over time (especially common in the case of batch processes) and process variability ("upset" conditions) must be taken into consideration.

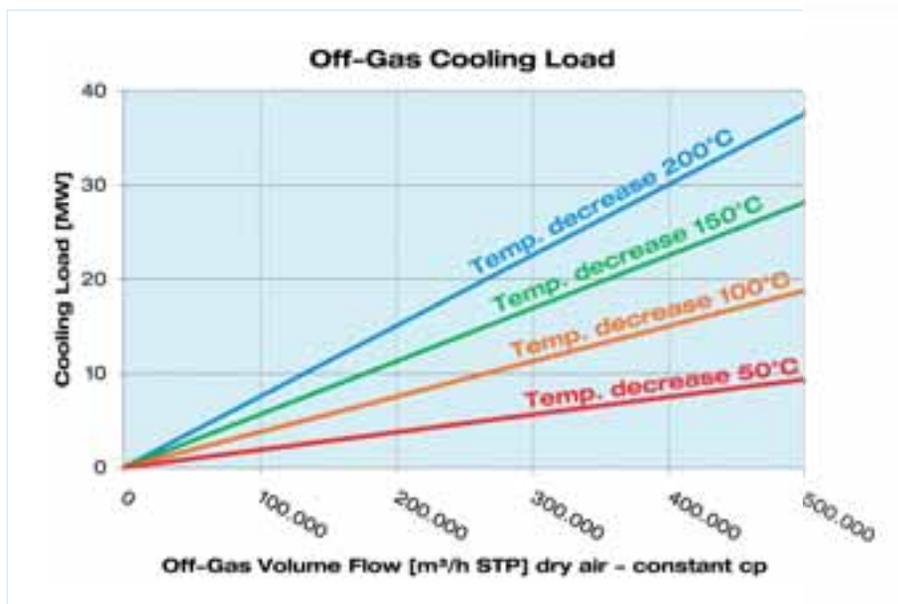
Essentially, Scheuch's product program covers three (3) available cooling processes:

- Cooling (regeneration) using air-to-air heat exchangers

- Cooling using a mixed air cooling system
- Cooling using a gas conditioning tower

Heat exchangers transfer heat energy from the exhaust gas to the cooling air. The dominant design is the **air-to-air heat exchanger**, which is usually operated in cross flow or cross counterflow mode. This heat exchanger is the right system for dry exhaust gases. In Scheuch's so-called bundled tube heat exchanger, the gas to be cooled is fed to the tube interior via inlet hoods and cooled on the exterior side in cross flow mode with ambient air supplied by axial fans. Depending on the requirements, bundled tube heat exchangers are manufactured in one- or two-stage designs that can be used on the cool air as well as the exhaust gas side of an installation.

Depending on the application, bundled tube heat exchangers are manufactured with a variety of tube dimensions and special emphasis is placed on a coherent concept for the struc-



tural engineering and temperature compensation of the tube bundle. The temperature-controlled cooling fans are installed in groups or individually and the heat exchangers can be equipped as needed with an integrated emergency cooling system.

The **mixed air cooling process** is used particularly when minor cooling is required only on an occasional or temporary basis, or in cases where cooler partial airflows are already available in the plant in question. The mixed air components are sucked into the mixing area by temperature-controlled valves or by axial fans.

In **evaporative cooling**, the exhaust gas is cooled by the injection of water into the pipe system or into an apparatus called a gas conditioning tower or GCT (in parallel flow to partial or complete saturation). The cooling capacity is based on the heat amounts required to heat the water, for evaporation and for heating of the steam, whereby the evaporation enthalpy is predominant. While the required cooling capacity and the amount of water required for it are easy to determine using a heat balance calculation, we have been able to accumulate

a wealth of technical know-how through practical experience over the past few years with respect to outfitting the GCT and its control system.

The driving force behind the evaporation process is the temperature of the exhaust gas. This means that in the case of comparable thermal outputs, a GCT operating at low temperatures must as a rule have significantly larger design dimensions than one operating at higher temperatures. In a Scheuch GCT, cooling water is injected using a one-component atomization nozzle or by means of compressed-air atomization (two-component nozzle). The preferred direction for airflow within the GCT is in a vertical direction and depending on the application or planning requirements, the exhaust gas flows from the top to the bottom of the GCT ("top-down") or from the bottom to the top of the GCT (bottom-up). In contrast to air-to-air heat exchangers, this system is less sensitive to deposits and caking.

When short-term temperature fluctuations occur (above all during batch processing), plant components also function as heat reservoirs.



1) Air-to-Air Heat Exchanger

Depending on the process demands of the exhaust gas to be cooled (cooling speed, avoidance of cooling below the dew point, etc.), multi-stage designs are possible on both the process gas and cool-air side.

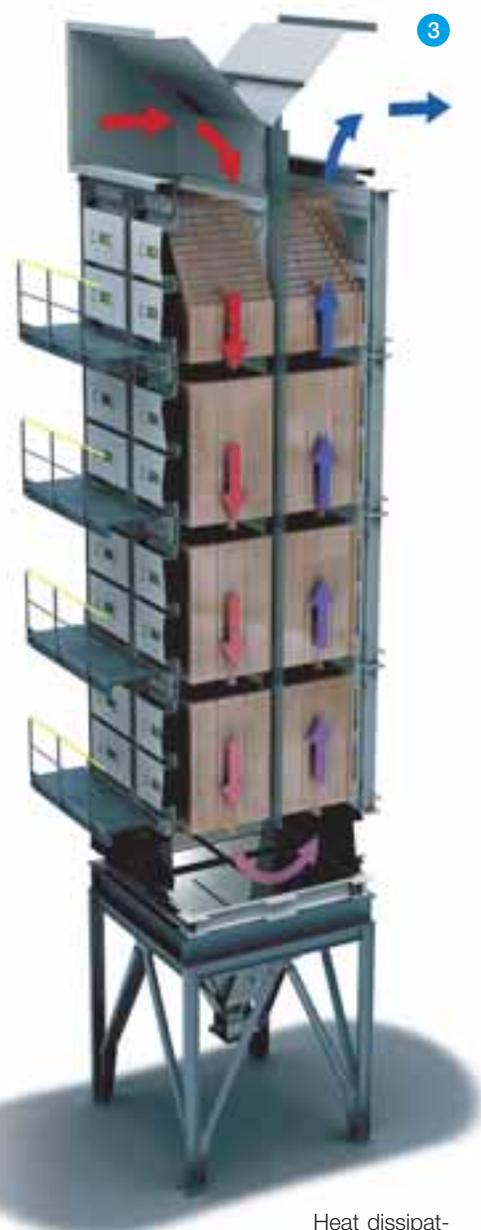
2) Gas Conditioning Tower - "Bottom-Up"

Gas Conditioning Tower - "Top-Down"

Gas conditioning towers are used above all in the cement industry, when hot process gas from the preheating tower must be cooled directly to a filter inlet temperature of at most 120° Celsius.

3) Mass Cooler

Depending on the required cooling capacity, mass coolers are designed either as standalone coolers or as individual mass cooler packets inserted into extraction lines.



Heat dissipated into pipe walls leads to material warming (mass storage effect). A Scheuch **mass cooler** uses this effect in a targeted way to avoid temperature spikes in exhaust gases. The packets of metal plates installed in the mass cooler have been thermo-technically engineered and optimized to keep the mass of the installed plates low.

All of the Scheuch cooling systems described here have been systematically designed on the basis of customer requirements and are optimized for each respective application. In the case of all designs, overriding importance is given to key areas such as fluid mechanics (inflow/outflow, pressure loss), acoustical engineering, wear and tear, deposits and caking, spark removal and accessibility, so as to ensure not only the best possible technical solution for the particular cooling challenge, but cost-effective plant operation as well.