Compact multi-purpose jet scrubbing units

Tailor-made gas scrubbing systems in compact design for Chemical Industry, Pharma & other Branches

Compact gas scrubbers are intended for exhaust gas treatment in chemical laboratories, pilot plants and small-scale chemical and pharmaceutical businesses. They are designed to absorb harmful substances, cool gases, condense vapors and separate dust. In addition, they can be used for the recovery of valuable materials and the production of chemical products.

This article gives an overview of the various available system configurations and options to adapt the design and material of the units to the process specific requirements.

Principle of operation

Jet scrubbers operate according to the injection principle (see Figure 1). They have no pressure loss but create a pressure gain. The circulating scrubbing liquid serves as a motive medium and conveys the induced gas through the jet scrubber pipe. Therefore, no mechanical fan is required for extracting and conveying the gases.

After passing through the jet scrubber part, the gas-liquid mixture is separated in a centrifugal separator. While the scrubbing liquid flows back into the liquid tank, the gas flows through a counter-current column, which is operated with either the scrubbing liquid from the reservoir or, if required, with fresh scrubbing liquid and/or with make-up of active chemical compounds. Droplets of entrained liquid are separated by a demister located at the top of the column prior to the gas outlet.

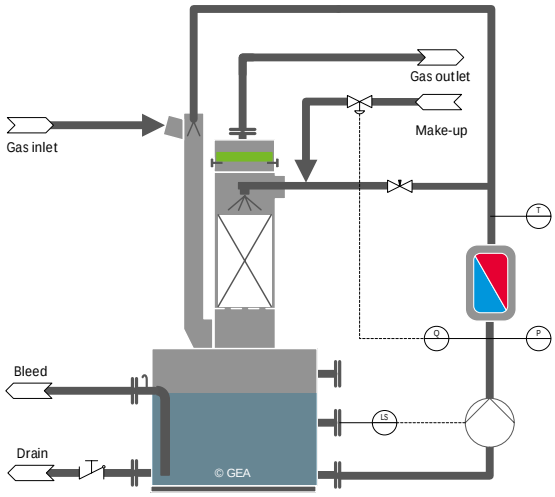

Figure 1: *Standard configuration of a compact jet scrubber*

Gas scrubber configurations

Figure 1 shows the basic configuration of a compact jet scrubber, which can and in fairly all cases also is adapted and altered according to the customer-specific requirements and needs. Depending on process-specific requirements, a randomly packed column, a structured packing column or a tray column can be used. The use of structured packing can be advantageous in order to reduce the overall height, the pressure drop or the amount of scrubbing medium. Droplets of entrained liquid are separated by a demister located at the top of the column in front of the gas outlet. In special cases, the jet scrubber can also be designed as a quench to cool hot gases with inlet temperatures of up to 1,000 °C. In special operating cases it is also required to separate aerosols. However, these aerosols can neither be effectively separated with a jet scrubber nor with a counter-current column. Therefore, if aerosols occur in the process, the scrubber can be equipped downstream with a suitable separator.

Fields of application

Compact gas scrubbers have a broad range of applications, are resistant to fouling and need low maintenance effort. The operating conditions of these units range from ambient to gas temperatures of up to 1,000 C and pressures up to 20 barg. The compounds that have been treated most frequently are given in Table 1. The gaseous species range from inorganic molecules, sulphuric components, common bases and acids to organic compounds. Some components have to be treated not only by neutralization but by oxidative treatment with for instance H_2O_2 or NaOCl in the liquid phase, e.g. when mercaptanes (R-SH) or other VOC are to be treated.

Table 1: *Most frequent gaseous and liquid/solid compounds to be treated*

Gaseous compounds	Liquid/solid compounds
· Halogens F_2, Cl_2, Br_2, I_2 · Hydrohalic acids HF, HCl, HBr, HI · Sulphur components SO_2, SO_3, H_2S, R-SH, CS_2, COS · CO_2 · Bases, e.g. NH_3, Amines · Alcohols and carboxylic acids · Carbonates · Epoxides, e.g. EO and PO · Aldehydes · Ethers · Other organic compounds	· Aqueous aerosols of SO_3/H_2SO_4, hydrohalic acids (e. HF, HCl, etc.), ammonia salts (NH_4Cl) · Dust and droplets (particle size > 1-2 µm) · Other particles coming from the process

Material selection

Due to the different chemical nature of the pollutants and the applicable scrubbing liquids or reaction products, the range of applied materials of construction for the compact gas scrubbers consequently is very broad. Figure 2 gives an indication of materials that can be combined to enable high chemical durability and therefore long-term usage of the units, the applicable pressure ranges and relative prices.

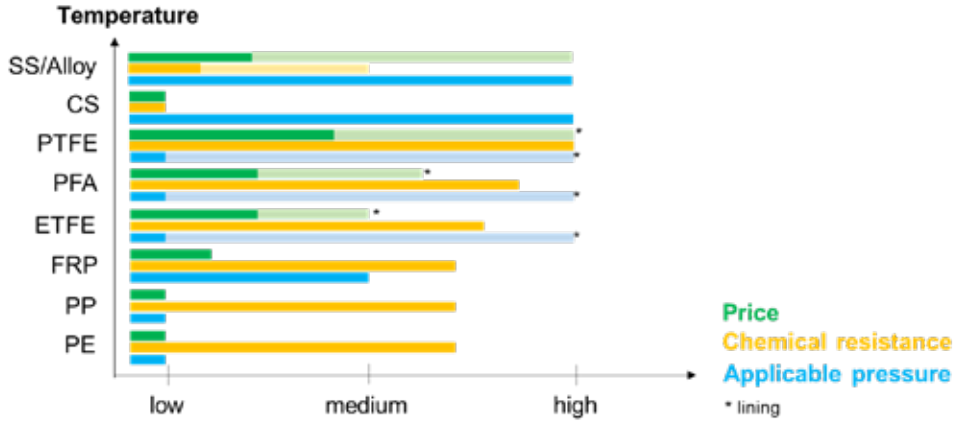

Figure 2: *Indicative classification of pressure range, chemical resistance and price of various materials of construction of compact gas scrubbers*

Standard materials of construction are polyethylene (PE) or polypropylene (PP), which only differ by their applicable temperature range and their UV stability. PE and PP show already very good chemical stability and are preferred for ambient pressure and low temperature applications. For higher chemical or thermal stability requirements copolymers of e.g. ethylene/tetrafluoroethylene (ETFE) or perfluoroalkoxy vinyl ether (PFA) or even polytetrafluorethylene (PTFE) lining can be used. Combined with housing of either fiber reinforced plastics (FRP), carbon steel (CS) or various stainless steels (SS) / alloys a very high mechanical, thermal and chemical resistance of the construction can be realized. The choice of the right material of construction is very important, and the corresponding design and manufacturing processes require extensive know-how and long-term experience.

Recent Application Examples

The first example shows a mobile gas scrubber designed as a multipurpose unit for a broad application range. The design conditions were -1 / +2 barg and 0 / +80 °C. Gases from several reactors containing methanol, toluol, ethanol, DMF, methylene chloride, and other acids and caustic vapors needed to be cleaned by acidic or caustic washing liquids. The inlet gas volume flow was 10 m^3/h. The scrubber is designed for installation in hazardous zone (Category 1 and 2), gas category IIB and IIC. The materials of construction are all electrically conductive: tank, stainless steel coated with ECTFE-el; piping, scrubber and column lined with PP-el, plate heat

exchanger made of Alloy 59. All connecting branches were designed as milk pipe screw connections. The scrubber was CE certified and had been supplied ready for operation including a process control system.

Figure 3: *Mobile compact gas scrubber for hazardous zone 1and 2*

The second example shows a compact gas scrubber system for the purification of a SO_X-containing exhaust gas stream. The scrubber inlet was designed for an inlet gas temperature of approximately 200 °C and therefore made of Hastelloy C4 (2.4610). The rest of the scrubber was fabricated in polypropylene in order to reduce costs. For safety reasons the jet scrubber was equipped with a submerged end. Due to the fact that the plant had to be installed in a rack provided by the customer, a very space-saving installation was realized. To remove the SO_3 aerosols from the gas stream, the scrubber is additionally equipped with a candle filter for aerosol separation. The scrubber also contains an integrated caustic soda dosing station with a separate dosing pump for direct connection to an IBC.

Figure 4*: Compact gas scrubber system made of Hastelloy and PP with aerosol separation*

The following unit was designed to fit into a particularly small footprint (2.2 x 2.6 m). It is used for abatement of SO_2 from vessel vent streams and was installed recently in the chemical industry. The capacity of the system is to treat max. 25 vol.-% SO_2 in N_2 with an overall flowrate of 300 m^3/h with caustic soda. Since the system is required to cope with inlet gas temperatures of up to 150 °C and prospectively also for multipurpose applications, it is entirely made of PTFE-lined stainless steel and PFA-lined FRP equipment. The sustainable process design is

optimized for load-flexible consumption of NaOH (depending on concentration of SO_2) and therefore minimum use of utilities. Additional features are the redundant pump lines for optimized maintenance intervals and design of the apparatus in accordance with ATEX directive.

***Figure 5**: Multipurpose gas scrubbing unit for the chemical industry with a particularly small footprint*

The next example unit was designed to fit for a particularly small footprint and to be installed in a hazardous zone. The scrubber is applied for the treatment of a gas flow containing HCl. The maximum gas volume flow is 100 m^3/h. The washing liquid, water or caustic soda, is cooled by a heat exchanger made of graphite. The used pump is magnetically coupled and coated with PFA due to the corrosive nature of the washing media. The entire gas scrubber is made of electrically conductive PE. All fittings were made of PFA/GGG, the column of glass in order to detect color changes in the gas and liquid and any blocking of the system.

***Figure 6**: Compact gas scrubber for a gas flow containing HCl to be installed in hazardous zone.*

Fig. 7 shows a scrubbing unit specially designed for cleaning of exhaust air containing HCl and H_2SO_4 from a storage tank extraction with a volume flow of 20 m^3/h to values according to TA-Luft. Due to the presence of aerosols, an aerosol separator was installed downstream of the compact gas scrubber. The system was made of PP material for indoor installation. Due to the heat generated in the absorption process, a heat exchanger is integrated into the system to cool the scrubbing medium. As measuring techniques, a thermometer, a manometer, a pH measurement, a flow measurement as well as two limit switches were integrated into the supply tank.

***Figure 7**: Scrubbing unit with aerosol separator for exhaust air containing HCl and H_2SO_4*

Conclusions

Amongst others, especially the chemical industry requires complex gas treatment solutions for either production processes or emission control applications. The complex chemical processes present often require special and tailor-made gas scrubbing equipment in terms of configuration, operating conditions and material of construction. Very often solutions based on the use of thermoplastic or FRP material or perfluorinated liners can be used instead of conventional alloy material, enabling a better long-term stability at lower CAPEX. During the recent decades GEA has supplied various small-scale compact gas scrubbing units which were non-standard but tailor-made solutions to fit the customer specific needs best.

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