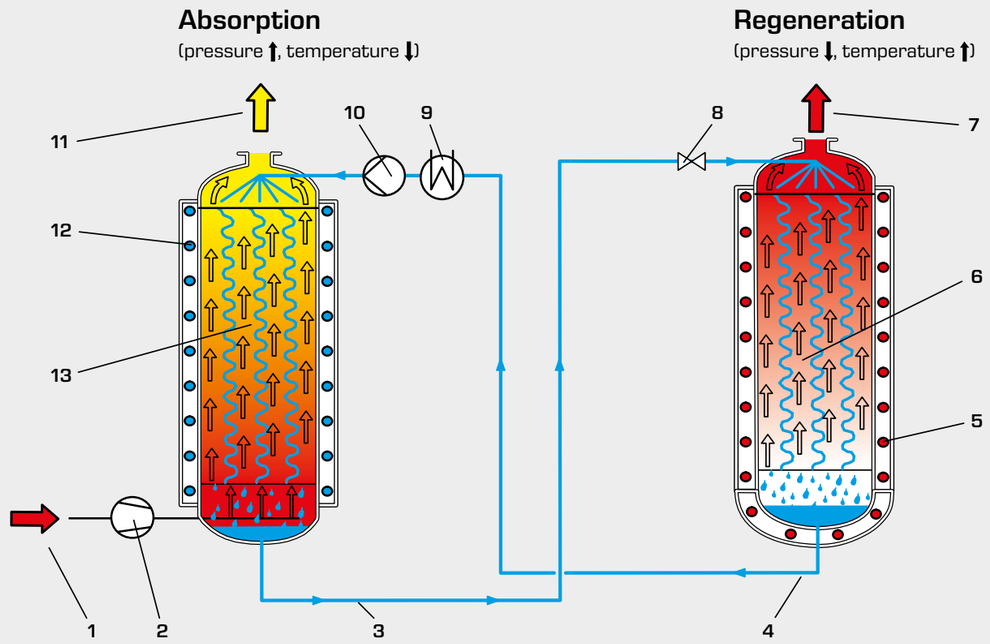
Basic knowledge

Absorption

Absorption is used to remove one or more gaseous components from a gas flow using a solvent. Absorption can have different aims:

- The gaseous component to be removed is a product that is wanted.
- The gaseous component to be removed is unwanted. This could be the case when removing contaminantes from an exhaust gas flow.
- Production of a liquid; one example would be obtaining hydrochloric acid by absorption of HCl gas in water.

At least three substances are involved in the absorption: the gaseous component to be removed (absorbate), the carrier gas and the solvent (absorbent).



Absorption system: **1** gas flow with component to be removed and carrier gas, **2** compressor, **3** solvent, charged with component to be removed, **4** regenerated solvent, **5** heating, **6** desorption column, **7** removed gaseous component, **8** expansion valve, **9** cooler, **10** pump, **11** carrier gas, **12** cooling, **13** absorption column

An appropriate solvent is used, depending on the gaseous component to be removed. The solvent selectively dissolves the gaseous component i.e. the solvent primarily absorbs the component(s) to be removed and not the carrier gas. High pressures and low temperatures enhance absorption. Depending on the type of solvent, the gas is either absorbed by physical dissolving (physical absorption) or chemical bonding (chemical absorption).

To remove the gaseous components from the solvent, an absorption stage is normally followed by a desorption stage for regeneration of the solvent. Here, high temperatures or low pressures are used to reduce the solubility of the gases in the solvent, thus expelling them. The solvent can therefore be recycled for further use.

Basic knowledge

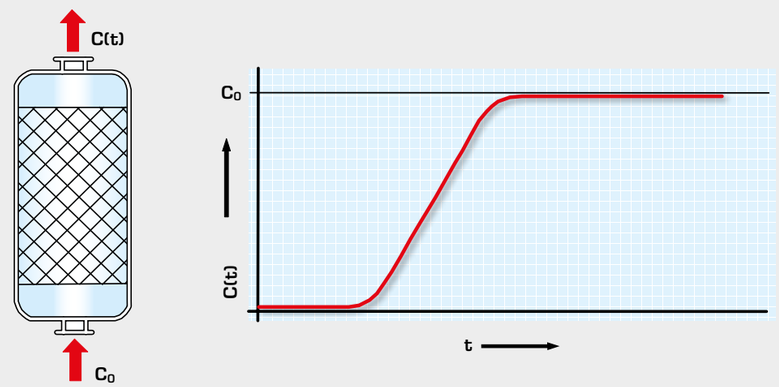
Adsorption

Adsorption is used to remove individual components from a gas or liquid mixture. The component to be removed is physically or chemically bonded to a solid surface.

The component removed from a gas or liquid mixture by adsorption can either be a product that is wanted or an impurity. In the latter case, the aim could be to clean exhaust gases.

The solid is referred to as the adsorbent and the adsorbed component as the adsorbate. Where possible, the adsorbent should only bond the adsorbate and not the other components in the mixture to be separated. Other important requirements for the adsorbent are a large specific surface (high porosity) and good regeneration properties. Activated carbon is a frequently used adsorbent.

As adsorption is enhanced by low temperature and high pressure, high temperature and low pressure are used to promote regeneration, i.e. desorption. This means that water vapour or hot inert gas can be used to regenerate the adsorbent.



Idealised breakthrough curve for a fixed bed adsorber:

C_0 inlet concentration of adsorbate in fluid, $C(t)$ concentration of adsorbate in fluid at adsorber outlet

If a fluid with a constant concentration of a component to be removed (adsorbate) flows into a fixed bed adsorber, the adsorbate is initially completely adsorbed in the lower area of the fixed bed (adsorbent). The fluid leaving the adsorber therefore contains no adsorbate at this time (illustration).

As time progresses, the adsorption capacity in the lower area of the fixed bed decreases. The adsorbate is gradually bonded to the adsorbent in higher and higher areas. This corresponds to the migration of the mass transfer zone (MTZ) over time. When the MTZ has migrated entirely through the fixed bed, breakthrough occurs. The adsorbent cannot bond any more adsorbate over the entire height of the fixed bed. The concentration of the adsorbate at the adsorber outlet then corresponds to the inlet concentration.

Breakthrough curves are used to design fixed bed adsorbers. Their shape characterises the sorption behaviour.