Aerosol formation in a double-stage acid recovery process

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Keywords: heterogeneous nucleation, waste gas cleaning, hydrochloric acid.
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For treating flue gases from waste incineration containing acid-forming substances like HCl or HBr, absorption columns are often used for gas cleaning purposes. Depending on the process conditions, supersaturation can occur inside these columns, with consequent aerosol formation due to heterogeneous nucleation (Schaber, 1995). Acidic aerosol droplets, which are carried out of the device along the gas stream, cause high pollution and therefore require additional effort for droplet separation.

In order to separate the acid from the flue gas and recover it for subsequent applications double-stage scrubbing processes as shown in Figure 1 are often used. In the first stage the main part of the acid forming substance is absorbed in a highly concentrated circulating acid. At high acid concentrations the vapor pressure of the acidic component cannot be neglected, so that the gas is leaving the first stage still loaded with the pollutant. Depending on the liquid composition in the second stage, simultaneous heat and mass transfer can cause supersaturation and aerosol formation. To avoid this effect, caustic or salt solutions, effecting water vapor pressure depression, are used for the second scrubber.

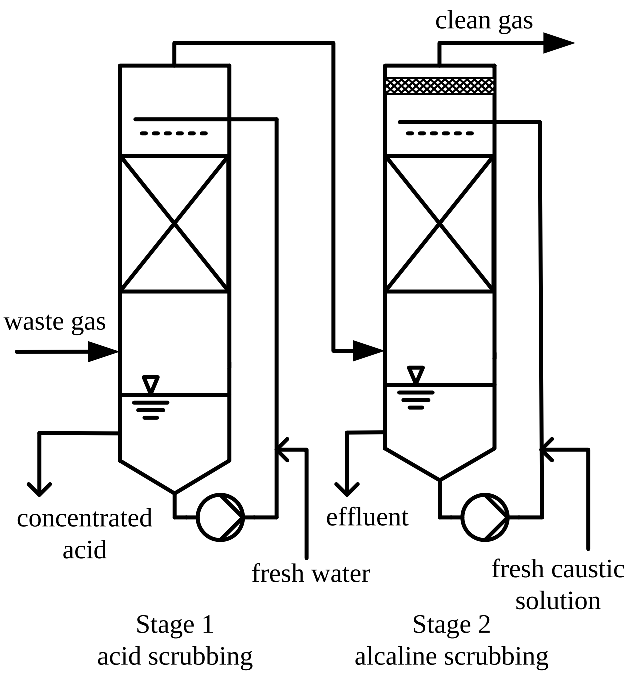

Figure 1. Scheme for a gas cleaning process with acid recovery using two serial wet scrubbers.

To model the simultaneous heat and mass transfer between gas and liquid phase, and between gas phase and aerosol droplets, the simulation tool AerCoDe (Ehrig *et. al.*, 2002) is used. It can predict the saturation along the phase interface and give information on the aerosols formed inside the contact device. In addition, recent code upgrades allow to simulate vapor pressure reduction and evaporation of droplets. With the new AerCoDe version so obtained, it is now possible to support the design of optimal scrubbing processes with respect to acid recovery and operation costs.

In the example given below, waste gas is assumed to be moist air loaded with hydrogen chloride and 10^6 heterogeneous nuclei per cm^3, which is a typical number concentration for flue gas. The second scrubber is operated with a sodium hydroxide solution, so that newly formed acid is neutralized immediately. Figure 2 shows the theoretical saturation without droplet activation (dashed line) and the actual saturation considering aerosol formation (solid line) for different mass concentrations of sodium hydroxide. The droplet diameters of the resulting aerosol droplets are displayed in Figure 3. Due to the reduced activity of water with increasing electrolyte concentration, the maximum saturation is reduced and the gas is undersaturated in the equilibrium state. In an undersaturated atmosphere, the droplets evaporate and clean gas will leave the device.

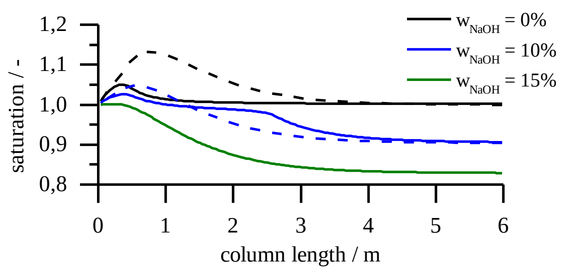

Figure 2. Saturation in the second stage

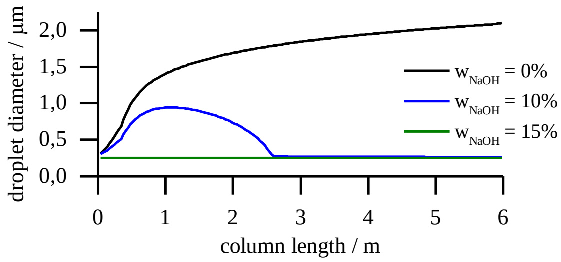

Figure 3. Droplet diameters in the second stage

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Ehrig, R., Ofenloch, O., Schaber, K., Deuflhard, P. (2002) *Chem. Eng. Sci.* **57**, 1151-1163.