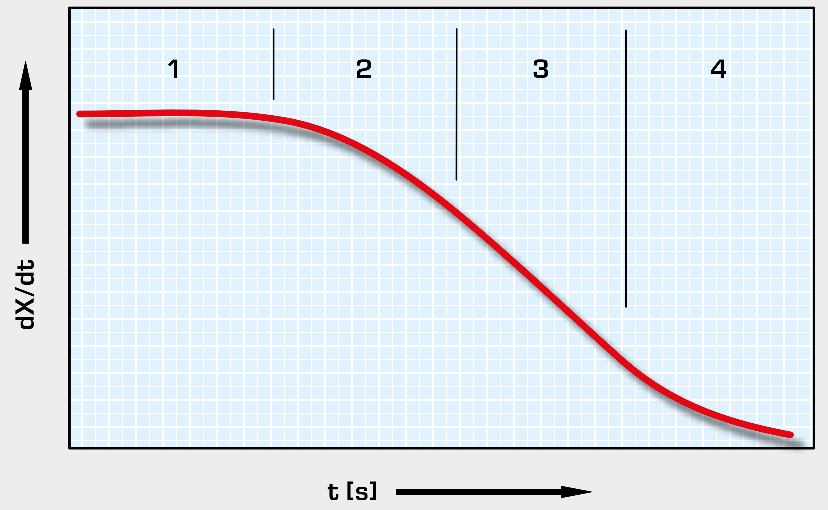
Basic knowledge

Drying

In general, drying refers to the removal of moisture from solids, gases or liquids. For drying gases and liquids, adsorption is normally used. The food technology industry is an example of where drying solids on a large scale is important.

Thermal drying of solids involves removing moisture from the material by vaporisation or evaporation. The drying characteristics depend on how the moisture is retained within the material. In the first instance, the liquid adhering to the surface of the material to be dried can be removed by vaporisation or evaporation. Once this liquid has been removed, drying of the moisture contained within the capillaries and pores of the material begins. The drying speed reduces due to the need to overcome capillary forces and diffusion resistance. Crystal water which is bonded into the crystal structure of the material, can only be removed by intense heating in addition to low drying speed.



Drying characteristics of a solid with division into drying sections (1-4):

dX/dt drying rate, **X** moisture content [kg (water)/kg (dry solid)], **t** drying time;
1 surface moisture, **2** capillary moisture, **3** pore moisture, **4** moisture in crystal structure

A wide range of process engineering principles are used in drying, due to the variety of industrially moisture containing materials. These materials can have extremely different behaviours.

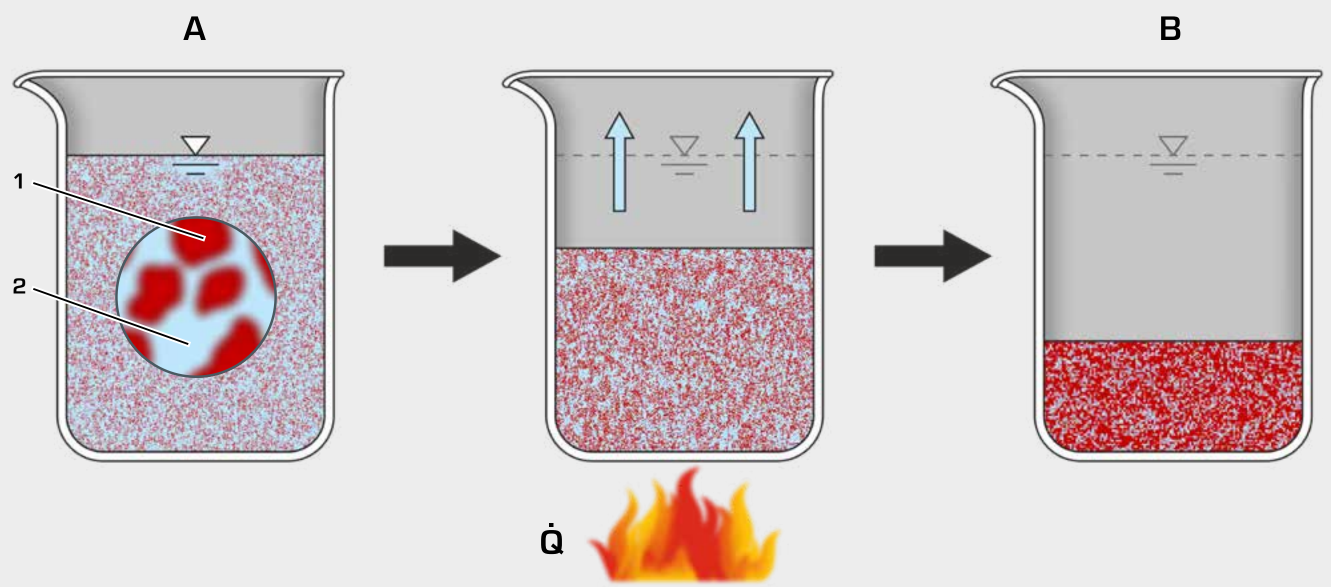
The following unit operations can be distinguished:

- **Convection drying**
  A flowing gas transfers the heat necessary for drying to the material by convection. As well as delivering heat, the gas is also used to remove the moisture given off by the material.
- **Contact drying**
  The material is placed on or is passed over heated surfaces. Heat is predominantly transferred to the material by conduction.
- **Radiation drying**
  The material absorbs emitted electromagnetic radiation from sources of radiation (e.g. infrared radiators). Heating and evaporation occur not only at the surface of the material but also within it.
- **Freeze drying**
  The frozen material is placed in a vacuum below its triple point. Moisture is removed from the material, by changing it directly from a solid to a gaseous state.
- **High frequency drying**
  The material is exposed to high frequency electrical fields between the electrodes of a plate capacitor. A part of field energy is absorbed by the material resulting in internal heating and removal of moisture.

Basic knowledge

Evaporation

In the context of thermal process engineering, evaporation is understood to be the separation of a solvent from a solution. An example of a solution is salt water, in which salt (the dissolved solid) is present in the solvent, i.e. water. The addition of heat exclusively evaporates the pure solvent (water in this example) from the solution and carries it away. The remaining solution thus has a higher concentration of dissolved solid than before the addition of heat.



Principle of increasing the concentration of a solution by evaporating the solvent:

A solution before evaporation of solvent, **B** more concentrated solution after evaporation of solvent, **$\dot{Q}$** addition of heat;
1 dissolved solid, **2** solvent

The aim of evaporation can be to obtain the solvent, to create a concentrate solution or to precipitate the dissolved solid by crystallisation.

Industrial applications of evaporation include:

- Increasing the concentration of solutions i.e., salts, alkalis, acids, plastic solutions, fruit and vegetable juices, milk etc.
- Obtaining products i.e., sugar from juices, salt from brine, drinking water from sea water.

Different evaporator designs are used depending on the aim of the separation process. Essentially they are heat exchangers in which steam is normally used as the heating medium. The solution can pass through the evaporator tubes once (straight-through evaporator) or several times (circulation evaporator). For solutions containing temperature-sensitive substances, thin film evaporators are used. These limit the retention time of the solution in areas with high temperatures.