Lecture 15

Drying of Solids

Drying involves the removal of moisture (either water or other volatile compounds) from solids, solutions, slurries, and pastes to give solid products, which often, after drying, are final products ready to be packaged. In the feed to a dryer, the moisture may be a liquid, a solute in a solution, or a solid. In the first two cases, the moisture is evaporated; in the latter case, the moisture is sublimed. The term drying is also applied to a gas mixture in which a condensable vapor is removed from a noncondensable gas by cooling, and to the removal of moisture from a liquid or gas by sorption. This lecture deals only with drying operations that give solid products in various sizes and shapes.

Drying is widely used in industrial processes. Applications include the removal of moisture from: (1) crystalline particles of inorganic salts and organic compounds to cause them to be free-flowing; (2) biological materials, including foods, to prevent spoilage and decay from micro-organisms that cannot live without water; (3) pharmaceuticals; (4) detergents; (5) lumber, paper, and fiber products; (6) dyestuffs; (7) solid catalysts; (8) milk; and (9) films and coatings.

Drying can be expensive, especially when large amounts of water, with its high heat of vaporization, must be evaporated. Therefore, it is important, before drying, to remove as much moisture as possible by mechanical means such as expression; gravity, vacuum, or pressure filtration; settling; and by centrifugal means.

Because drying involves vaporization or sublimation of the moisture, heat must be transferred to the material being dried. The most commonly employed modes of heat transfer for drying are: (1) convection from a hot gas in contact with the material, (2) conduction from a hot, solid surface in contact with the material, (3) radiation from a hot gas or hot surface in view of the material, and (4) heat generation within the material by dielectric, or microwave heating. These different modes can sometimes be used to advantage, depending on whether the moisture to be removed is on the surface of the solid and/or inside the solid.

Of importance in the drying of solids is the temperature at which the moisture evaporates. When the first mode is employed and the moisture is a continuous liquid film or is rapidly supplied to the surface from the interior of the solid, the rate of evaporation is independent of the properties of the solid and can be determined by the rate of convective heat transfer from the gas to the surface. Then, the temperature of the evaporating surface is the wet-bulb temperature of the gas provided that the dryer operates adiabatically. If the convective heat transfer is supplemented by radiation, the temperature of the evaporating surface will be higher than the wet-bulb temperature of the gas. In the absence of contact with a convective-heating gas, as in the latter three modes, and when a sweep gas is not present, such that the dryer operates nonadiabatically, the temperature of the evaporating moisture is its boiling-point temperature at the pressure in the dryer. In evaporators, if the moisture contains dissolved, nonvolatile substances, the boiling-point temperature will be elevated.

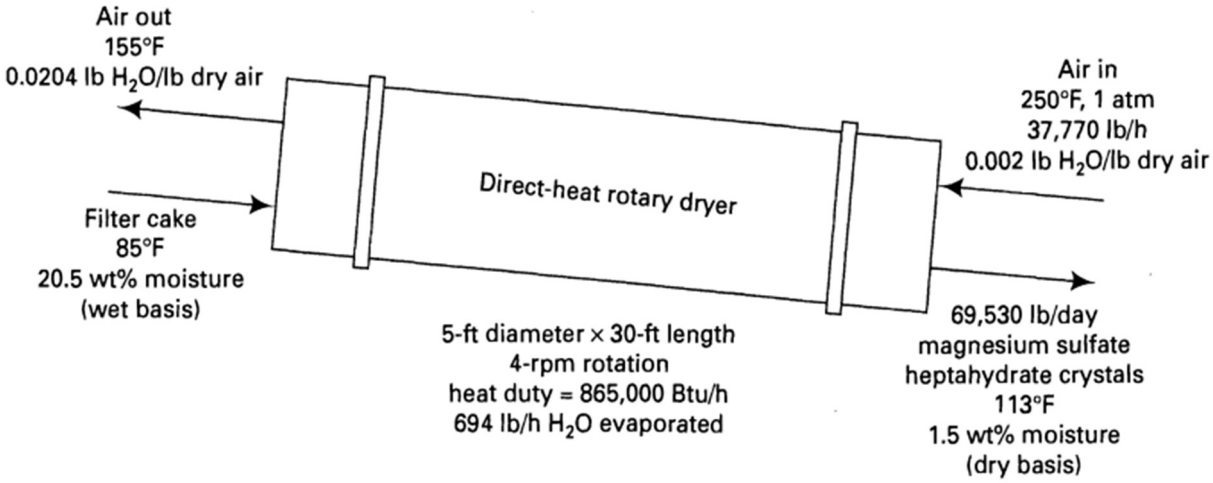

Figure 1 Process for drying magnesium-sulfate heptahydrate filter cake