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CHAPTER 42

DEHUMIDIFICATION BY SORBENT MATERIALS

Types of Sorption Dehumidifiers; Liquid Sorption Systems: Liquid Sorbents, Machine Operation and Design; Solid Adsorption Systems: Solid Desiccants, Machine Operation and Design; Sorption Dehumidifiers for Elevated Pressures; Applications for Sorption Dehumidifiers; Moisture Load Calculations; Vapor Transfer to Dehumidified Space

DEHUMIDIFICATION as used herein is the reduction of the water-vapor content of a given volume of air or other gas. The term thus describes a special case of dehydration which covers the removal of moisture in any form from matter. The degree of dehumidification required varies greatly with different applications, and is one of the prime considerations influencing the choice of a method.

Dehumidification may be accomplished by chilling, as described in Chapters 19, 23, and 41, by the use of sorbents, or by compression in combination with chilling, sorbents, or both chilling and sorbents.

Sorbents are substances which have the property of extracting and holding other substances (usually gases or vapors, e.g., water vapor) brought into contact with them. All materials are sorbents to a greater or lesser degree. The weight of water held by a substance will increase or decrease, depending upon whether the vapor pressure of the water held by the substance is less or greater, respectively, than the partial pressure of water vapor in the surrounding atmosphere. As generally used, however, the term sorbents refers to those materials having a capacity for moisture which is large compared to their volume and weight. Such materials are divided into two general classifications:

1. *Absorbent*—A sorbent which changes either physically, chemically, or both, during the sorption process. Calcium chloride is an example of a solid absorbent, while liquid absorbents include solutions of the halogen group (lithium chloride, lithium bromide), and the ethylene glycols.

2. *Adsorbent*—A sorbent which does not change physically or chemically during the sorption process. Certain solid materials, such as activated alumina, silica gel, activated bauxites, and activated charcoal have this property. The action of adsorbents, most of which adsorb some gases and condensible vapors besides water vapor, is selective. Thus, in the case of a mixture containing both water and organic vapors, silica gel would remove the water vapor in preference to the organic vapors, while the reverse would be true in the case of activated carbon. The selective property of adsorbents is made use of in some instances for the removal of objectionable and contaminating vapors from an air or gas mixture. (See Chapter 7.)

LIQUID ABSORPTION SYSTEMS

Liquid Absorbents

A liquid absorbent has the property of absorbing moisture from, or adding moisture to, the air, depending upon the vapor-pressure difference between the air and the solution. The equilibrium vapor pressure of the solution is dependent upon the temperature and concentration of the solution.

Absorbents for a liquid dehumidifying system should have the following characteristics:

1. Suitable vapor-pressure characteristics. The absorbent should not crystallize at temperatures 10 to 15 deg below the temperature range used in the operating cycle.
2. Noncorrosive, odorless, nontoxic, and nonflammable.
3. Stability. It should not break down over the range of use.
4. Low viscosity and good heat-transfer characteristics.
5. Widely available and economical to produce.
6. Capable of being regenerated at temperatures obtainable with low-pressure steam.

The equilibrium contact dew point is plotted against contact temperature for various concentrations of a typical organic liquid absorbent in Fig. 1. The same data for a typical inorganic absorbent is shown in Fig. 2. The concentration of the liquid absorbents used in commercial equipment is dependent on the temperature of the cooling medium, and on the latent and sensible heat-removal requirements.

The equilibrium contact dew points in Figs. 1 and 2 show the dew point of air in equilibrium with the liquid absorbent. Reference should be made to the published performance data for commercial apparatus for the solution of air-conditioning and air dehumidification problems. Fig. 3 shows a rating curve for a liquid absorbent dehumidifier using lithium chloride solution.

Liquid Absorption Operation

The operating cycle of a liquid absorption system with extended-surface contactor coils is shown by Fig. 4. For dehumidifying operation the strong absorbent solution is pumped from the sump of the unit and sprayed over the contactor coils.

The hygroscopic solution at the required temperature and concentration is in intimate contact with the air which is flowing over the coil surface in the same direction as the liquid absorbent. Equipment is also available for flow countercurrent to the flow of liquid absorbent. Moisture is absorbed from the air by the solution due to the vapor-pressure difference between the air and the liquid absorbent. The moisture content of the outlet air can be maintained at a constant condition by automatically regulating the flow of water through the cooler with a modulating water valve.

The heat generated in absorbing moisture from the air is called the heat of condensation of the water vapor in the solution. This consists of the latent heat of condensation of water vapor and the heat of solution or the heat of mixing. The heat of mixing varies with the liquid absorbent used and with the concentration and temperature of the absorbent. The solution is maintained at the required temperature by cooling with city, well, refrigerated, or cooling tower water, or refrigerant flowing inside the tubes of the contactor coil. The quantity of water required is a function of the water temperature and the total heat, either sensible, latent, or both, removed from the air by the hygroscopic solution.

The dry-bulb temperature of the air leaving the liquid absorbent contactor is a function of the temperature of the liquid absorbent and the amount of contact surface between the air and the solution. In most commercial equipment the