Dehumidification and Humidity Control

Dehumidification is a unit operation in which the moisture present in the air is removed and made dry to the required level (concentration). It can also be called as drying in the air.

The reverse process, *i.e.*, increasing the moisture content in the air and making it more wet, is also a unit operation and known as Humidification. Application of this in Pharmaceutical industry is very much limited and negligible. Air with increased moisture content is essential in the growth of certain organic cultures. Humidification is extensively used in textile industry, where sections like spinning and weaving require a relative humidity of 70% to 90%. Hence humidification process and related matters are not dealt here. Dehumidification is very much employed in Pharma industry for several purposes. Hence a detailed study of this unit operation becomes essential.

Dehumidification of air can be achieved by condensing the water vapour present in air as moisture to the liquid from water and removing it. The same object of removing water vapour can also be achieved by absorbing and adsorbing the water vapours on suitable media and thus making the air dry. These transfer processes depends upon the temperature and moisture content that are already present in the air. It is an equilibrium process. In the normal environmental conditions, the air has a certain humidity which differs in day time and night time, from season to season in the country, as also from place-to-place like coastal and non-coastal areas geographically. But in industry, air with a steady and constant humidity is required throughout the process and in whole year, to achieve quality of product and to get good yield.

11.1. PSYCHROMETRIC CHART

Psychrometric chart is also called as Humidity chart or Hygrometric chart. In this chart humidities (expressed as pounds of water per pound of dry air) are plotted as ordinates against (Fahrenheit or centigrade) temperatures as abscissas for a pressure of 1 atmosphere. Any point on this chart represents the temperature and humidity of a definite sample of air. The curved line marked "100%" gives the humidities of saturated air at various temperatures. Mixtures of air and water vapour represented by points above and to the left of the saturation line cannot ordinarily exist. The curved lines below the line for saturated air represent various per cent humidities. The line for humid heat is plotted with humidities from right-hand edge of the chart as ordinates, against BTU along the top of the chart as abscissas. The lines for the specific volume of dry air, and for the saturated volume, are plotted with temperatures as abscissas and cubic feet per pound of dry air along the left edge of the chart as ordinates. The humid volume of a sample of air at a given temperature and humidity can be found by linear interpolation between the line for saturated volume and the line for the specific volume of dry air.

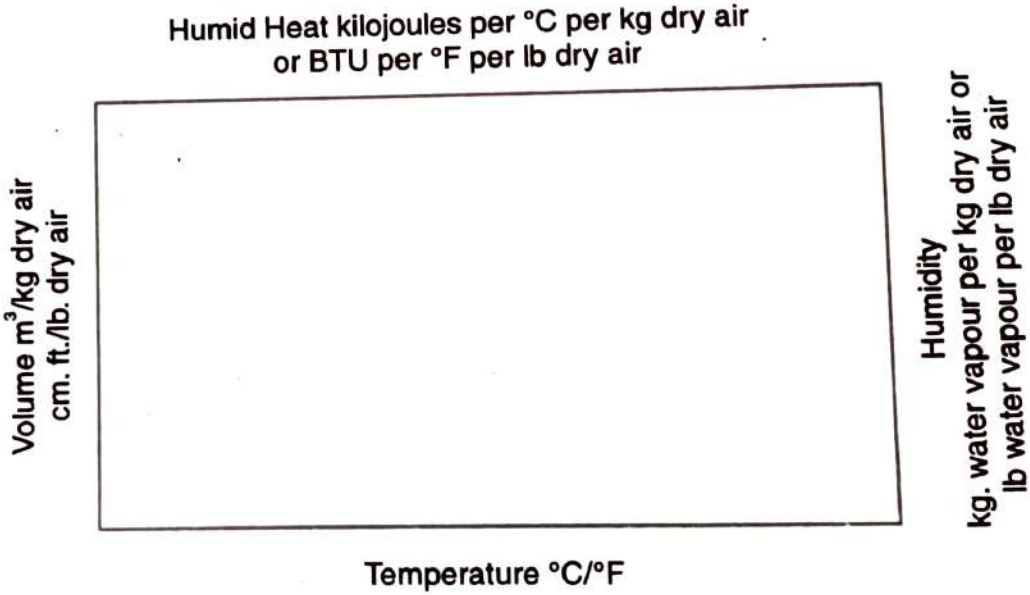

Fig. 11.1. Psychrometric chart model.

11.2. MEASUREMENT OF HUMIDITY AND RELATIVE HUMIDITY

I. Dew Point Method

The dew point of wet air is measured directly by observing the temperature at which moisture begins to form on an artificially cooled polished surface. The polished surface is usually cooled by evaporation of a low boiling solvent such as ether; by vaporisation of a condensed gas such as CO_2 or liquid air, or by a temperature regulated stream of water. Referring to the humidity chart, the humidity of the area corresponding to the dew point can be found.

Although the dew point method may be considered a fundamental technique for determining humidity, several uncertainties occur in its use. It is not always possible to measure precisely the temperature of the polished surface or to eliminate gradients across the surface. It is also difficult to detect the appearance or disappearance of fog; the usual practice is to take the dew point as the average of the temperature when fog first appears on cooling and disappears on warming.

II. Wet-Bulb Method

The most commonly used method for determining the humidity of a gas stream is the measurement of wet and dry bulb temperature. The wet bulb temperature is measured by contacting the air with a thermometer whose bulb is covered by a wick saturated with water. If the process is adiabatic, the thermometer bulb attains the wet bulb temperature. When the wet and dry bulb temperatures are known, the humidity is readily obtained from the psychometric chart. In order to obtain reliable information, care must be exercised to ensure that the wet bulb thermometer remains wet and that radiation to the bulb is minimal.

Again, as with the dew-point method errors associated with the measurement of temperataure can cause variation and difficulty.

Use of Humidity Chart. (*i*) From the dew point temperature go up on the *y*-axis to point (*a*) on the 100% saturation line. Following from this point horizontally on *x*-axis will give the humidity H (See Fig. 11.2).

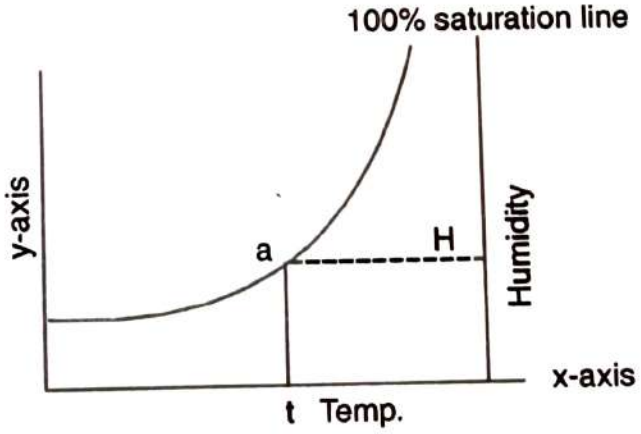

Fig. 11.2. Humidity chart (a portion).

Uses of Dehumidifiers in Pharmacy

1. In the manufacture of empty hard gelatin capsules.
2. In the hard gelatin capsules powder mixing, filling, sealing and packing areas.
3. In the manufacture of soft gelatin capsules.
4. In the manufacture of dry syrup preparations.
5. In the processing, filling and packing of hygroscopic powder dosage form and nutrition products.
6. In the tablet manufacturing, punching and packing areas, as the moist atmosphere may pose sticking and pitting problems.
7. In sugar coating and film coating of tablets.
8. In the antibiotic powder processing areas and dry powder filling in vials, as most of the antibiotic powders are quite hygroscopic. If they absorb moisture during processing and filling, their potency may come down fast and they may form lumps and cakes which will not go into the solution when reconstituted by the physician before injecting them to patients.

handy and quick to know the RH. The hair will contract when humidity decreases and expand when it increases which is linked to the dial reading. (See Fig. 11.10)

11.4. DEHUMIDIFICATION EQUIPMENTS

The moisture present in the air is physically absorbed using suitable material known as desiccant. This may be carried out as a batch operation or on a continuous basis.

Dessicant is a material which attracts water vapour, causing it to condense upon its surface, without absorbing or being absorbed, by the moisture. Its physical structure does not change in the process. *e.g.* Silica gel, Alumina, Calcium chloride, Anhydrous sodium sulphate, H_2SO_4 acid, Glycerol, P_2O_5 LiCl (silica geel and Alumina Al_2O_3 are adsorbing type rest are absorbing types).

(A) In the batch process, there is no movement of the desiccant—they are periodically removed, recharged and loaded back into the system. At the best, they may be loaded on circular discs or plates, connected centrally through a shaft and to a motor running at a very slow speed for easy unloading and loading of dessicants. Fig. 11.11.

(B) The continuous physical adsorption process unit consists of two parts—Dehumidification sector and Reactivation sector. There is a perforated metal bed rotating clockwise moving through both the sectors in a cycle. The two sectors known as compartments are isolated by silastic seals. Dessicants are charged on the perforated disc bed. Small blowers are provided for the fresh air and hot air flow.

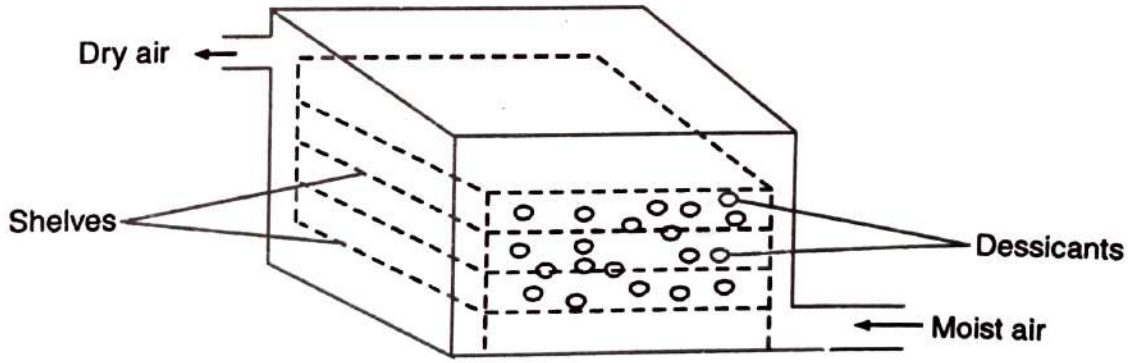

Fig. 11.11. Batch dehumidifier.