Spray Dryer

Objectives

Learning the working principle of the spray dryer system and drying a solution by spraying.

Theory

The term drying can generally be defined as the process of removing small amounts of liquid (moisture) from the solid. A moist substance loses moisture when it comes into contact with a low flow of hot gas. Various drying devices are used for drying of solids. These; tray dryers, carrier dryers, tower dryers, rotary dryers, fluid bed dryers, flash dryers, spray dryers, thin layer dryers, drum dryers.

Spray drying is one of the oldest drying methods and several technologies used to convert a liquid, muddy or low viscosity paste into a dry solid (free flowing powder) in a single unit process. Spray dryers; minerals and minerals are found in almost every industry, such as the food industry and dairy, pharmacological agents, detergents and paint industry.

The process of spray dryers is continuous and easy. Automatic control of the process can be applied easily. As long as the drying conditions are constant, the product quality does not change during the drying process, regardless of the time of the drying process. Spray dryer can be designed in accordance with the desired product criteria. Spray dryers are suitable for drying heat sensitive and heat resistant materials, aseptic and hygienic drying conditions. Disadvantage of spray dryers have high hardware cost according to the product capacity. With these features, spray dryers are the most important drying system of today.

Spray dryers can be co-flow, counter-flow or squirt-flow depending on the temperature sensitivity of the material, desired dry product characteristics and system selection. These dryers can be either direct or non-direct and can use a variety of heat sources. In co-flow systems, hot gas (carrier) is introduced along with the feed at the top of the tower and extracted from the discharge cone through an extraction trough. In the squirt flux, the product is sprayed vertically upwards and changes direction in the drying chamber.

It consists of a spray dryer system, feeding and solution distribution unit, hot gas production and transmission lines to the system, drying room, solid-gas separation units, product discharge unit. In addition, the system includes sections such as pipelines, pumps, blowers and control systems that provide connection and transmission.

The thermal efficiency of the spray dryer generally depends on the operating temperature. Two different yield definitions are given below;

$$\eta_0 = \frac{T_1 - T_2}{T_1 - T_A}$$

$$\eta_E = \frac{T_1 - T_2}{T_1 - T_S}$$

T_1 and T_2 air inlet and outlet temperatures, respectively,

T_A ambient air temperature;

T_S is the adiabatic saturation temperature corresponding to the humidity of the incoming air at the T_2

Evaporation efficiency (η_E), indicates the degree to which the air used in drying approaches saturation.

Total efficiency (η_o) shows the fraction of the total heat input used for drying.

Dry-Wet Thermometer Temperatures (Psychometric Method)

The moisture content of humid air is found with the help of measuring dry and mourning thermometer temperatures and the psychometric diagram.

When a liquid with a very small mass is initially evaporated in adiabatic conditions in a large volume of unsaturated continuous gas stream at the same temperature as itself, the liquid cools itself due to the evaporation heat required to evaporate the liquid from the liquid. After a while, sensible heat is transferred from the gas, which has a higher temperature than the liquid.

As a result, the temperature of the liquid reaches a steady state; In this case, the heat required for the liquid to evaporate and for the steam to reach the temperature of the gas is balanced by the sensible heat transfer from the gas to the liquid. This steady-state temperature is called <u>wet bulb thermometer temperature.</u>

During the equilibrium, the temperature of the liquid is always lower than the temperature of the gas (dry thermometer) in which it evaporates. If the gas phase is initially saturated with liquid vapor until saturation, neither evaporation nor wet bulb thermometer temperature drops. Although the principle of calculating the amount of steam carried by the gas phase by measuring the temperature of the wet and dry thermometers can be used for every steam-gas system, it is mostly used for air-water steam systems.

In this way, measuring the relative humidity of the air by measuring the dry and wet bulb thermometer temperatures is called a <u>psychometric method</u>.

Apparatus

Experimental setup is shown in Figure 1.

• The device is connected to the electricity. The air inlet temperature is adjusted.

• Air flow is adjusted.

• It starts the compressor and is adjusted to full capacity.

• The heater is operated.

• Distilled water is put into the pump feed and the pump is started. The pump is run at the fast setting first and the distilled water is adjusted to the optimum speed as soon as it reaches the jet.

Instead of distilled water, the solution to be dried in the sample container is put.

- When the solution to be dried reaches the jet, spray drying has started. The dried powder product is passed through the cyclone and is observed in the main collection container.
- The product passes through the cyclone and is collected in the main collection container.
- Operating conditions such as temperature, solution and airflow rates can then be changed.
- When enough products are collected, the experiment is ended. The operated sections are closed in the reverse order of the opening sequence.
- The air inlet and outlet temperatures and the humidity of the outlet current are recorded.
- Necessary cleaning of the experimental setup is done.

Figure 1. Spray dryer test system

Calculations

During the experiment, the following data are entered into the table for each parameter change.

	Parameters							
	Inlet Temperature		Quantitiy		Aspiration Power		Pump Speed	
Inlet Temperature:								
Outlet Temperature:								
Environmental Temperature:								
Ambient Temperature (Wet Thermometer;								
Relative Humidity Corresponding To Ambient Temperature								
Relative Humidity At Exhaust Outlet								
Amount Of Substance								
Amount Of Substance Measured In The Collecting Container								
Aspiration Rate								
Pump Speed								

- Set up mass and energy balances on the spray dryer.
- Determine the percentage and humidity of the solid obtained, taking into account the amount of solids in the feed.
- Calculate the «total" and "evaporation" yields using Equation 1 and 2.
- Determine the adiabatic saturation temperature using the psychrometric method.

The psychometric diagram for the air-water system is given in Figure 2.[4]

Discussion

- Discuss the effects of system parameters on efficiency using the data you obtained.
- Are there any deficiencies you observed in the experimental setup? Please write if you have suggestions for improvement. What else can you do with the setup?

Questions

What are the other types of dryers besides spray dryers? Which type of dryer can generally be preferred for which materials?

What types of substances are spray driers not used for?

Investigate an industrial facility around you, using a spray dryer and investigate which substance is dried and the dimensions of the dryer.

What kind of design do you make if you are asked to design a spray dryer test rig? Draw a figure and make your explanations

References

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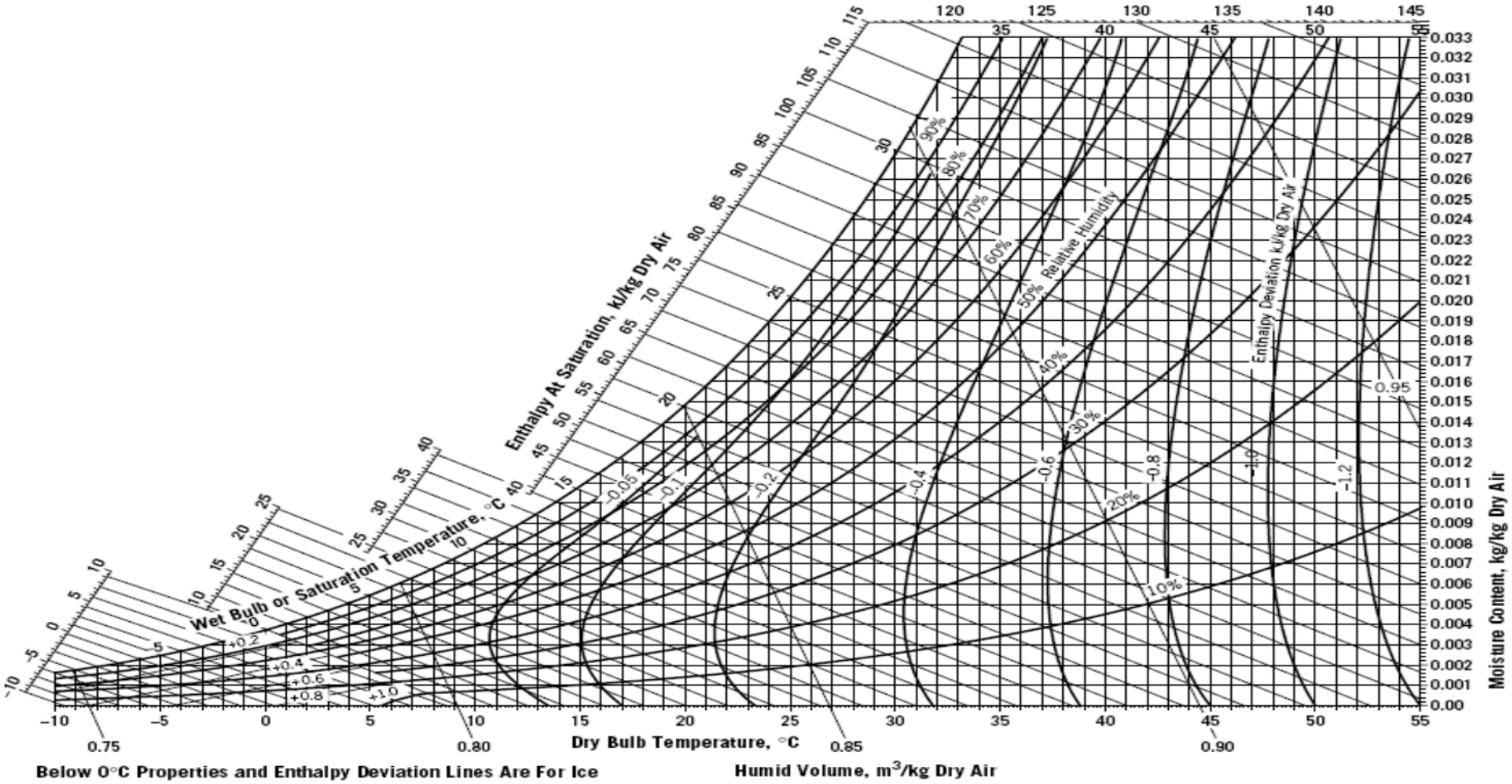

Figure 2. The psychometric diagram for the air-water system [4].