Whatever the weather

Bente Nielsen, industry manager at Munters, looks at how the weather affects spray drying

Installation of desiccant air dehumidifiers improves spray drying processes inside the spray drying chamber and in the sections handling the final dried powder. Here is an overview of how desiccant air dehumidification works, and the benefits that it brings to the spray drying process in the form of higher plant capacity, less downtime, process stability and lower cost of investment and operation.

Two different ways

Most powder handlers have experienced hygroscopic products causing trouble in powder silos, conveying lines and anywhere else where the dry powder is handled, and it is common practice to use desiccant air dehumidification to overcome such problems.

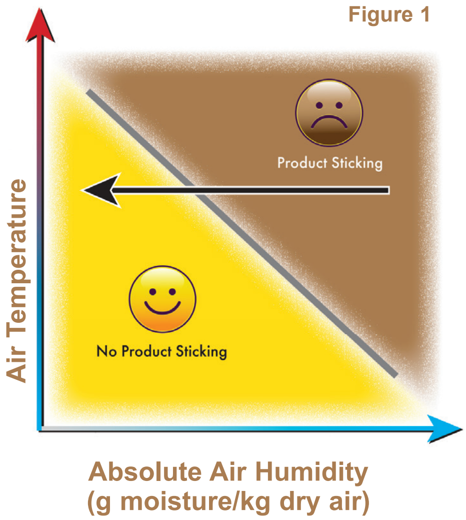
It is, however, less well known in the industry that desiccant air dehumidification improves the spray drying process itself, as simply by bringing the drying air humidity level down, the drying air can then carry more water away from the product being dried.

Product sticking

Some products are easily dried and never stick to the internal dryer walls, whereas other products are very difficult and readily stick to the dryer surfaces, resulting in poor product quality, dryer fouling and plant downtime.

Product sticking happens at higher air temperature and humidity, as illustrated in figure 1 (below). The stickiness curve is characteristic for a given product and its moisture content. Operators may have tried to increase the dryer inlet temperature to get away from powder sticking, only to realise that this enhances the stickiness problem, simply because the higher inlet temperature results in more evaporation and thus a higher chamber outlet air humidity, meaning that it goes right back into the stickiness area.

Figure 1



In conventional spray dryers, sticking can only be prevented if dryer capacity is lowered. The amount of water evaporated from the product into the air will then be reduced, the outlet air becomes less humid and the product will no longer stick. Many plant managers have experienced spray dryers operating at unchanged conditions year-round suddenly running into problems if the ambient weather becomes more humid on a hot summer day. The powder starts to stick, and only reduced evaporation inside the chamber can bring the dryer back into trouble-free operation.

Inlet air dehumidification reduces the humidity of the dryer outlet air, and it will in this way bring the process back to the area with no sticking, and do it without reducing the dryer capacity.

Dry winter conditions

Ambient air humidity influences the spray drying process, and even though many spray dryers operate at constant capacity and under stable conditions year-round, most processes can be optimised for a higher capacity through inlet air humidity control.

Some companies have developed their own automation programmes to adjust the spray drying process to the fluctuating weather. In this way sticking can be controlled, but then plant capacity varies with the weather and not with the need in the factory, which would be preferred.

In both temperate and tropical climates, the ambient air humidity varies from season to season, from day to day and even during the day. Keeping a constant spray dryer capacity means that the spray dryer operates regardless of the dryer inlet air humidity, and the spray dryer is not utilised fully during dry times. In simple words, a spray dryer operating at a constant capacity no matter the ambient weather runs 'humid summer conditions' all the time, and the drying air and dryer volume are not efficiently used.

Desiccant dehumidifiers installed up-front of the spray dryer offer a constant low air humidity level and allow for full dryer utilisation, no matter the ambient weather. The spray dryer operates at constant, high capacity, as it runs 'dry winter conditions' all the time.

Figure 2A

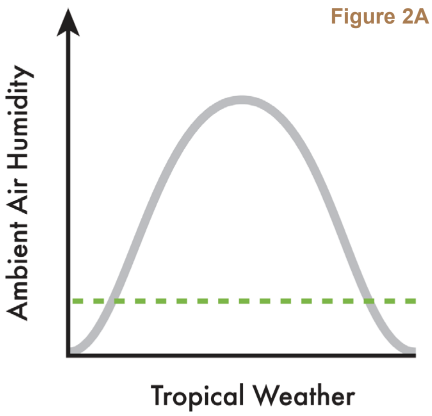
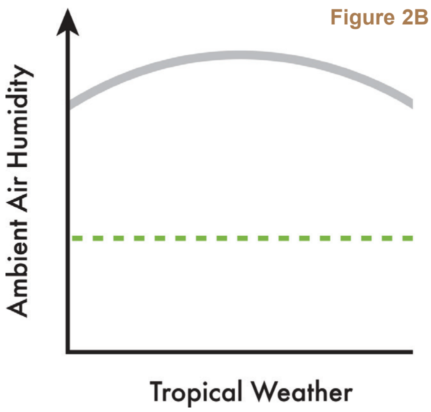


Figure 2B



Desiccant dehumidification can bring air humidity down with at least 12g/kg, for example from 14 to 2g/kg or from 22 to 10g/kg in one step without any use of chilled water. Figures 2A and B show how the ambient air humidity is controlled at constant levels in both temperate and tropical climates.

Air dehumidification to 10 g/kg in tropical areas could alternatively be done with chilled water. But ice water causes condensation in the process air, the energy cost is very high and the low temperature is difficult to reach. The modern desiccant dehumidifier can do better without pre-cooling. Then, later it can reheat the air, before it goes to the spray dryer, which needs the higher inlet temperature.

A constant spray dryer capacity eliminates a lot of issues with product quality, adjustment of dryer set points and production logistics.

Spray dryer capacity

Spray dryers usually run with a constant air flow to the process, and the dryer capacity can be expressed as the amount of water evaporated from the product into the air. Depending on the product stickiness characteristics, the dryer can run safely up to a given maximum air humidity at a given dryer outlet air temperature as illustrated in figure 1 (previous page). The drying rate is the difference between the dryer outlet air humidity and the inlet humidity.

Let us assume a product can dry to a spray dryer chamber outlet air humidity of 40g/kg. If the ambient air already contains 10g/kg humidity, the air can remove 30g/kg in a trouble-free process. If the ambient air instead contains 15g/kg, the air can only remove 25g/kg. This explains why many processors face sticking problems on hot, humid summer days, if drying parameters are not changed. On a clear, frosty winter day, however, the ambient air contains very little humidity. If the air humidity is as low as eg, 2g/kg, the same dryer can evaporate 38g/kg without powder sticking. Desiccant air dehumidification allows for such high capacity all year round.

The more difficult the product is to dry, the lower the dryer outlet air humidity. Figure 3 illustrates possible spray drying capacity achievement with air dehumidification for different products. As it appears from the figure, very difficult products cannot be dried in tropical climates unless the air has been dehumidified. All calculations are for a single-stage spray drying process.

Drying air temperature

All heat used for spray drying comes in the form of hot air. Because air flow to the spray dryer is usually kept constant and cannot be enlarged, additional capacity needs a higher air temperature difference.

Spray Dryer Capacity Improvements with Air Dehumidification

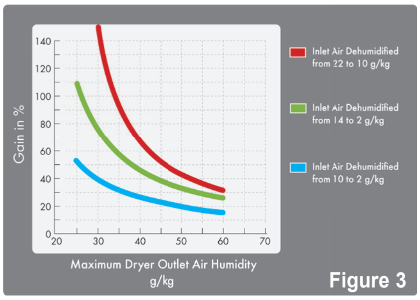


Figure 3

The dryer capacity depends linearly on the drying air temperature difference, meaning that a 10 per cent higher capacity requires 10 per cent higher air temperature difference. The dryer outlet air temperature will usually be kept constant, and the extra capacity can then be achieved after increasing the dryer inlet temperature. If, for example, a spray dryer operating at an inlet air temperature of 190ºC and an outlet temperature of 90ºC should produce 20 per cent more powder, the inlet temperature must be increased from its original 190ºC to 210ºC. Therefore increased inlet temperature must be acceptable for the product, and further that upstream and downstream equipment must be sized to handle the extra powder yield.

Dehumidification

Modern spray drying is a rather complex process where variations in raw materials and strict product specifications must be dealt with, and elimination of the weather impact on the process is a great help.

The desiccant dehumidifier is designed for maximum air dehumidification, meaning that the air will always leave the dehumidifier at design conditions, no matter the weather fluctuations. On humid days, the dehumidifier will operate at maximum duty, and during less humid times, dehumidifier regeneration is regulated for less water adsorption and less energy use.

When water adsorbs on the desiccant, latent heat is changed into sensible heat, which will be released as air at higher temperature. Hot air reactivates the desiccant as shown in figure 4 (right). This means that operation of the dehumidifier requires heat input and fortunately part of this heat is transferred to the final dehumidified air. The heat is therefore not a loss, as the higher temperature will save energy in the final air heating to the spray dryer inlet temperature. As a rule of thumb removal of 1g/kg humidity gives an air temperature rise of 3.6ºC, removal of 10g of water rises the air temperature from an ambient 20ºC to approximately 56ºC. Because dehumidified air possesses more drying capacity, a spray dryer retrofit usually adds up to 10-15 per cent energy savings per ton of powder produced.

Spray dryers can perhaps be smaller, require less space and use less utilities if air dehumidification is integrated at the onset of the design phase of a spray drying project. Air dehumidification allows higher capacity and less energy consumption, which means that for a given production capacity a smaller spray dryer may be big enough for a production capacity.

The reduced size of the dryer and the smaller building needed pays for the extra investment in a dehumidifier, and an increasing number of producers include air dehumidifiers in their new dryer investments or they go for retrofit of existing spray dryers with desiccant dehumidifiers.

Desiccant dehumidifiers

The principle of desiccant air dehumidifiers is illustrated in figure 4 (below). A rotor containing desiccant material rotates through two separated sections – one for process and one smaller for reactivation. Air passes through the process section, humidity adsorbs on the desiccant material, and the dry air leaves the rotor on the opposite side. The wheel rotates slowly, and the used desiccant comes to the reactivation zone. Here heated ambient air regenerates the desiccant, before it again moves into the process section. Dii

Figure 4