

Infant formula spray drying processes improve significantly when dehumidified ambient air is used for the drying process. Plant capacity goes up, sudden powder sticking inside the spray dryer ceases and dehumidified air improves powder cooling and general handling. All of these improvements make it easier to meet final product specifications and increase product shelf life.

### Infant formula products

Infant milk formulas are developed to be as close to human milk as possible, including as much of the natural nutrition and with as many of the functionalities as possible. Today's brands are far away from being just milk powders. Infant milk powders are produced either from fresh, liquid milk or from reconstituted skim milk powder with additional other ingredients.

A mother's milk changes its composition as the baby grows. First, it is rich in lactose and fat with a low protein concentration, then later the lactose level drops and the protein concentration goes up. Human milk contains certain nutrients and special functionalities, the value of which researchers are constantly struggling to understand and then finding ways of adding to their products. Relatively new are prebiotics, the long-chained carbohydrates GOS and FOS, which are present in large quantities in infant formulas. Another trend is the addition of probiotics, these being living bacteria, which improve digestion in the baby's stomach and gut.

Different ingredients change the drying properties of the formulations, generally making them stickier and more difficult to dry. Many dairies have moved into infant formula production, and all of them have arrived at the same conclusion: infant formulas are generally much more difficult to dry than ordinary whole and skim milk, and new advanced formulations are generally even more challenging.

### Product sticking

Products behave differently in spray dryers. Some are easy to dry, whereas others are sticky and may cause dryer fouling and plant downtime. Infant formulas, especially formulas for newborn babies, will readily stick to the dryer's internal surfaces unless the operator adjusts the drying conditions for the product.

Product sticking inside the spray dryer

# Keeping the powder dry

**Air dehumidification improves infant formula spray dryer performance, according to Bente Nielsen, industry manager – food at Munters**

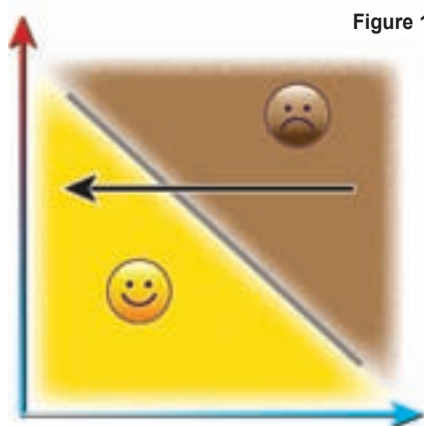


Figure 1

happens at higher air temperature and humidity, as is illustrated in Figure 1. The stickiness curve itself is specific for a given product composition and its moisture content. A higher concentration of lactose and lower concentration of proteins make the product stickier. Prebiotics such as GOS and FOS usually come as syrups, and make infant formula much stickier. Many producers have already experienced a significant drop in spray dryer capacity with prebiotics.

Powder sticking can be prevented if water evaporation from the product is lowered, outlet air humidity then drops, and the product will no longer stick, as in Figure 1. However, improved performance is paid for with reduced production capacity.

Milk may dry to an outlet drying chamber air humidity of 50g/kg or even higher depending on product specifications and dryer design. The same dryer will, on infant formulas, do much less, and an outlet air humidity of only 30g/kg is realistic for many of these products. If, as an example, have ambient air at 10g/kg for the spray drying process, each kilogram of air will be able to remove

40g when used for milk drying, but only 20g when used for drying infant formula. This example clearly illustrates the impact of product composition on spray dryer performance, and what happens when a dairy moves from milk powder to infant formula production; in this example the spray dryer capacity drops by 50 per cent.

Air dehumidification cannot change the behavior of different formulations, but it can improve the spray dryer capacity and performance. The more difficult the product is to dry, the more extra capacity can be achieved, as illustrated in Figure 2 below.

### Winter conditions

Many spray dryers are controlled to operate at constant conditions all year regardless of the ambient weather. But ambient air humidity strongly impacts spray dryer performance, and a constant capacity means that both the drying air and the spray dryer itself are not fully utilised. Air dehumidification will solve this problem.

All over the world, ambient air humidity varies from season to season, day to day and even within the same day. A spray dryer operating at constant capacity runs "humid summer conditions" all the time, and as a result, the drying air and dryer volume are not efficiently used. Controlling the spray dryer to operate in accordance with the ambient weather fluctuations will cure symptoms, but not be a real solution, as product sticking will be controlled at the expense of capacity. In winter this may be fine, but in summer, capacity is too low.

Desiccant dehumidification controls the air humidity itself, not the dryer, and it offers low air humidity independently of the weather. This enables the dryer

to operate at peak regardless of ambient weather and any fluctuations, and it now runs 'dry winter conditions' all the time.

In temperate climates, desiccant dehumidification can usually go as low as 2g/kg in one step without use of pre-cooling. In tropical climates, however, the ambient humidity is normally very high, so even the modern desiccant dehumidifiers going from, for example 22g/kg humidity to 10g/kg, may need pre-cooling to go further down.

Infant formulas generally dry at low capacity as discussed above, but the impact of air dehumidification is significant. When comparing the milk powder and the infant formula from before, after ambient air dehumidification from 10 to 2g/kg, capacities will go from 40 to 48 on the milk and from 20 to 28 on the infant formula. This gives 20 per cent extra yield on the milk, but 40 per cent more on the infant formula.

Let us look at the same products again, but this time dried in the tropics. We assume an ambient humidity of 22g/kg. The milk will now dry with a capacity of 28g/kg, whereas the infant formula will dry with a capacity of only 8g/kg. Dehumidification to 10g/kg, gives 43 per cent more capacity for milk, but when drying infant formula dryer capacity rises 150 per cent. Figure 2 illustrates the effect of air dehumidification on different products and it appears that the more humid the ambient air, the more benefits of air dehumidification.

One could argue that dehumidification to 10g/kg in the tropical areas could alternatively be done with chilled water, which is correct and has been common practice for years. However, ice water is troublesome, as it causes condensation in the process air and energy use is very high. From a hygienic perspective, condensation should be prevented if possible, especially in the infant formula industry.

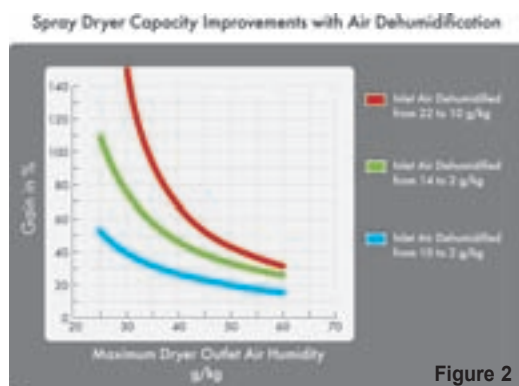


Figure 2

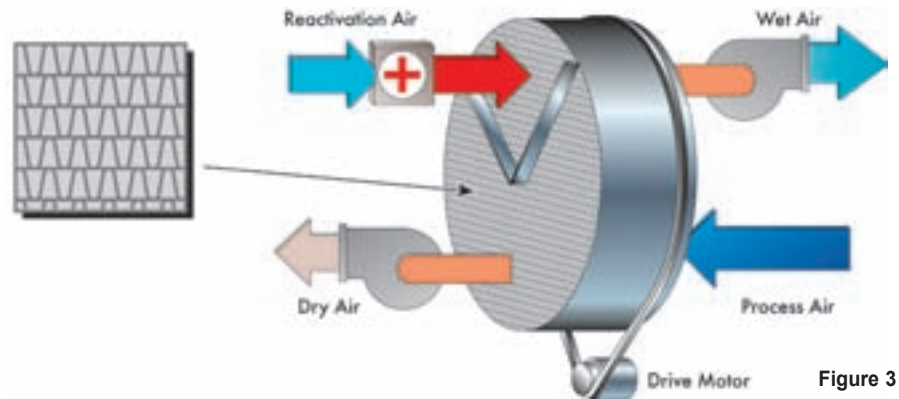


Figure 3

Chilled water is costly to use and difficult to achieve, the modern desiccant dehumidifier can in fact do the job without any cooling, nor re-heat the air again, before the air goes to the spray dryer.

### Drying air temperature

Heat for the spray drying process comes in the form of hot air. The air flow to the spray dryer is usually kept constant and extra energy needed for an enlarged capacity thus demands a higher temperature drop over the spray dryer. The operator will usually keep the dryer outlet air temperature constant and increase the inlet air temperature to gain extra capacity. The dryer capacity depends linearly on the spray drying air temperature difference. If for example, a spray dryer operating at an inlet air temperature of 190°C and a chamber outlet temperature of 90°C should produce 20 per cent more powder, the inlet temperature must be increased from its original 190°C to 210°C.

### Powder cooling

Dried milk and infant formula are usually cooled before storage and packing, with cooling taking place either in a fluid bed or in a pneumatic conveying line where dried powder is brought in contact with cooled air. It is important that the dry powder not regain water in the cooling process, as hygroscopic powders may form lumps and cause blockage. For infant formulas containing probiotics, a very low powder moisture concentration must be maintained to prevent bacteria from growing in the powder cans.

Traditionally, chilled water has been used for cooling the air to around 7°C. After cooling, the air is saturated with water and must be re-heated to lower its relative humidity. This means the air is heated even if it is to be used for

cooling, otherwise, the relative air humidity will be too high, and powders will re-absorb water.

In the case of hygroscopic powders and powders containing probiotics, chilled water is insufficient. However, desiccant dehumidifiers can achieve lower air humidity and prevent powders from regaining moisture during cooling. Further downstream, and where dry powder is handled, precautions must be taken to prevent powders from regaining moisture from air in contact with the powder.

### How it works

Figure 3 above shows how a desiccant dehumidifier works. The rotor containing desiccant material passes two sections as it slowly rotates. The first section is for the drying process and the smaller one is for reactivation of the desiccant material.

Ambient air flows through the process section. It dehumidifies when humidity adsorbs on the rotor material, and finally dry air leaves the rotor on the opposite side. After use, the desiccant enters the reactivation zone, where it regenerates by means of heated ambient air.

The newest desiccant material can reduce air humidity by at least 12g/kg. For example, it can reduce from 22 to 10g/kg, or from 14 to 2g/kg, without need for pre-cooling. The desiccant dehumidifier is designed for maximum air dehumidification, and on less humid days, reactivation will be reduced, keeping the final air humidity, but reducing energy consumption.

Humidity adsorption results in air temperature increases and 1g/kg humidity adsorption ups the temperature by approximately 3.6°C. Thus, after removal of 10g of water, air temperature goes from an ambient 20°C to approximately 56°C. Temperature rise and the increased capacity of the dehumidified air result in energy savings for the spray drying process. [Dii](#)