



SPRAY DRYING

By: J. Weernink

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Why are products dried?

- Lower transport costs.
- Lower packing costs.
- Longer durability

Lower transport cost

Lower transport charges speak for itself. The total volume of the product decreases considerably if the product has been dried.

Lower packing costs

Also the packing costs become lower by the smaller volume, but these costs become also lower because one can be enough with simple packing resources. For liquid products one must apply fluid-dense packing.

Longer durability

Longer durability has to do with bacterium increase in liquid products. Especially dairy products and foodstuffs are very sensitive for increase of bacteria. For this reason these products in liquid form deteriorate and are no longer suitable for human consumption.

To prevent this one can remove the water from the product. One of the most important factors for bacterium to be able to increase is water. If water has been removed, the bacteria will no longer grow. This does not mean that the bacteria are killed by removing water. The bacteria will only not grow any further. As soon as water is added to the product the bacteria reach life and start to grow again. For this reason it is very important that the dried products are not contaminated with bacteria. In the dairy industry Spray Drying is one of

the most important ways to remove water. Because Spray Drying is a relatively expensive manner to remove water, it is common to work with Evaporators before Drying with Spray Dryers. Evaporators do use much less energy than Spray Dryers. To give an impression of energy consumption of the different systems here is a table with some numbers:

- A 5 stage evaporator for the concentration of milk from 12 to 48% uses: 0.12 kilogram's steam per hour for every kilogramme of evaporated water.
- A Spray Dryer for drying Milk from 48% to 97% dry matter uses: 2 kilogram's steam for every kilogramme of evaporate water.

Of course then the question which follows is why Evaporators are not used for the whole process?

The answer on this is as follows: Evaporators with 5 effects have a certain liquid flow per effect.

Also there is a limited temperature difference over each effect. The liquid quantity is smaller after every effect, caused by the water vaporisation in the effect. Above 48% the viscosity becomes too high to pump the product through the Evaporator. For this reason from 48% dry matter Spray Dryers are used to concentrate the product further to a dry product. Spray Dryers can handle products with higher viscosity very well. The viscosity stipulates for an important degree the atomising system that can be used in a Spray Dryer.

The two most used atomising systems are:

- Wheel atomising
- High pressure systems with nozzle atomising

Wheel atomising

Wheel atomising is for example applied in standard Wide body Dryers. The system exists of a wheel with a product supply through the ash, or through two pipes beside the ash. In the wheel there are holes. By the high velocity of the

wheel the product is atomised to small droplets. Speeds of 6000 rpm with wheels of 400 mm diameters are very normal, at smaller diameters velocities of 12000 rpm are used also.



Picture 1



Picture 2

High pressure systems with nozzle atomisation

High pressure systems are used for almost all types of Dryers.

High pressure systems are used in: ` Wide body ' Dryers, ` Toll form ' Dryers and MSD Dryers. But also in Box Dryers and Belt Dryers high pressure systems are used. A high pressure system exists of a high pressure pump, a high pressure line, high pressure

valves and high pressure nozzles.



Picture 3

By means of changing the nozzle composition and as a result of this changing the pressure one can change the droplet size of the product. The largest advantage of the use of high pressure systems is the fact that the droplet size is nearly constant, in contrast to wheel atomising where the drops show always a large mixture. A very often used pressure for high pressure atomisation is: 180 à 200 bar.

The Spray Drying process

The Spray Drying process takes place in a large chamber. The product is atomised in very small drops in hot air. These drops will dry very rapidly, and dry particles fall to the lower part of the Dryer. Drying droplets is a physical process. We can compare in a simple manner by drying water in a pan.



Picture 4

If the water is left in the pan for a long one will see eventually that water has disappeared from the pan. Water then is evaporated. This evaporation can be accelerated by heating the water. The speed of the evaporation depends on the ability of the air above the water to take up the vapours. If during cooking of the water a ventilator blows away the humid air (therefore saturated air is replaced by fresh air)

evaporating of the water in the pan goes much more rapidly.

If the same quantity of water is put into another pan with much larger diameter than the evaporation also proves to go quicker.

The important items which for evaporation are:

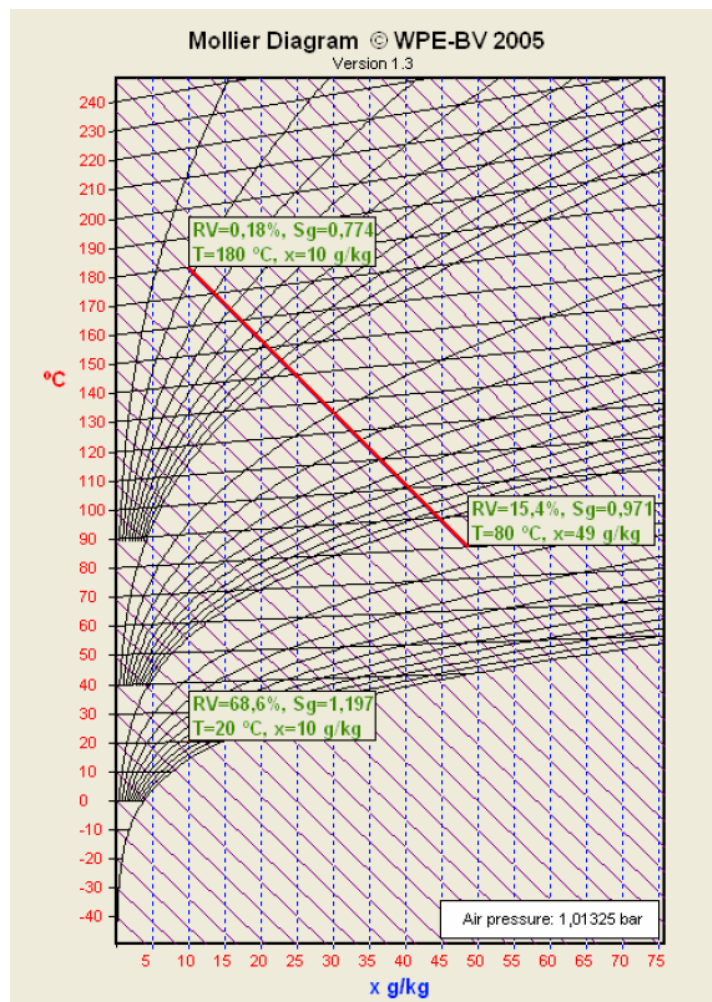
- The water absorption capacity of air
- The contact area between air and water
- The temperature of the water

The water absorption capacity of air

The water absorption capacity can increase by raising the temperature of air. This can be shown graphically in a Mollier diagram. A Mollier diagram is a graph which reflects the situation of air. And from which we can read by means of the temperature and the absolute moisture content the relative humidity. A couple items are given. It is known that the moisture content of the ambient air is always between 5 gram per kilogramme and 15 gram per

kilogramme. 5 gram are reached on sunny day in the winter with 15 à 20 degrees of frost at night. 15 gram are reached on a hot humid summer day in august. On average is the moisture content of air is around 8 à 10 gram per kilogramme

As an example we take 20 degrees Celsius and 10 gram moisture per kilogramme. This air has a relative humidity of approximately 68%. Air of 20 degrees Celsius can contain a maximum of 15 gram moisture. In that case the relative humidity 100% is.



Picture 5

What is Relative Humidity and what is Absolute Humidity?

Absolute humidity is the amount of water in the air in absolute sense. 10 gram moisture per kilogramme of air for example is a value for the Absolute Humidity. It means that per kilogramme of air there is 10 gram of water present. And for people who find the term kilogramme of air strange; air has indeed a weight although one does not feel it. 1 cubic meter of air of approximately 80 degrees Celsius weighs 1 kilogramme. At 20 degrees Celsius 1 cubic meter of air weighs approximately 1.2 kilogrammes. In both cases absolute dry air, therefore air without moisture in it. Relative Humidity is a number that indicates to what extent air is saturated. Air can contain a

maximum quantity of moisture at a certain temperature. If there is more moisture in the air the moisture starts to condense in the form of droplets. One can see this nicely on a foggy morning. The air then is saturated with moisture



Picture 6

and droplets are formed because the air can no longer hold the moisture. The air in this case has a humidity of 100%.

If we look back to the example of the air of 20 degrees Celsius then we can calculate what the Relative Humidity of the air with 10 grams of

moisture must be. It is: $10 \text{ divided by } 15\% = 66.7\%$.

This number deviates slightly from the value which we have found from the graph. This is caused round-offs.

If we heat the air of 20 degrees with a moisture content of 10 grams to 180 degrees Celsius by using an indirect heater, this air only has a Relative Humidity of 0.18% (the absolute moisture content has remained the same = 10 grams). Theoretically this air of 180 degrees Celsius can hold a maximum quantity of water of 7692 grams per kilogramme. This shows that the water absorption capacity of this air is still very high.

The contact area between air and water (product)

From the example with the pan it became clear that if the contact area is increased, the vaporisation speed is also increased. By making the droplets as small as possible during atomising the contact area is increased. This is shown in table 1.

When atomising 1 m³ liquid = 1000 litres to a droplet size of 500 microns (= 0.000500 meters) we get 15,278,874,537 drops with a total surface area of 12,000 m².

When we atomise we the same quantity liquid to a droplet size of 10 microns (= 0.000010 meters) then we get 1.909.859.317.102.740 droplets with a total surface area of 600,000 m².

Tabel 1

Total volume:	1 m ³	1 m ³
Diameter:	10 micron	500 micron
Diameter:	0,00001 m	0,0005 m
Volume droplet:	5,23599E-16 m ³	6,54498E-11 m ³
Area droplet:	3,14159E-10 m ²	7,85398E-07 m ²
Number of droplets:	1.909.859.317.102.740	15.278.874.537
Total area:	600.000 m ²	12.000 m ²

This shows clearly that if we make smaller drops the surface area is increased considerable.

The temperature of water (product)

The product can be pumped to the Dryer at several different temperatures.

Milk is normally heated to temperatures of approximately 50 to 70 degrees Celsius before it is send to the Spray Dryer. Raising the product temperature gives a small capacity profit during drying. During the drying process the temperature of the product goes to approximately 50 degrees Celsius. This happens during the time that 90% of water is evaporated. This is approximately the maximum saturation temperature of air. Just after approx. 90% of water has been evaporated the temperature of the product will raise further. At that moment the moisture must be transported inside the particle to outside before this can be dried. The temperature of the product remains almost always below the 75 degrees Celsius during drying.

Agglomeration during drying

During drying it is possible to agglomerate the product. This means that particles which have been atomised as small as possible are sticked together again. Because of this during drying larger particles are formed which have better dissolving properties. The agglomeration takes place in the top of the Dryer. By placing the nozzles in a such way that the particles will hit each other a moment when they are not yet entirely dry. These particles will stick to each other and agglomerates will be formed. If also the fine particles from the cyclones or the bag filters are send back to this area these particles will also

stick to the almost dry particles in the top, and as a result a better soluble product will be produced. Small particles dissolve difficult because they float on water and as a result are difficult to moisten.

Bacteriology during drying

During drying almost no bacterium killing takes place. This can be explained by the following:

Because the temperature of the product does not go above 50 degrees during the first phase of drying, and afterwards the temperature rises to 75 degrees, but then there is almost no more water in the product present. It can be compared with a sauna. If one is present in a sauna then the temperature can go up to 100



Picture 7

degrees Celsius without any problems for the people. But if then someone puts water on the glowing stones you have to get out as fast as possible. This indicates that dry air has little or no impact on living beings. Wet air has however much more impact.