Improve MC Control of Whey Powder

Using

The Delta T Moisture Sensing & Control System

By

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Introduction:

Three costly problems with currently-used moisture (MC) sensing & control systems are:

1. Lack of timely and accurate MC data to make control decisions.
2. Control algorithms are incapable of re-calculating new setpoint.
3. Lack of a simple, inexpensive evaporative load feedforward signal.

The Solution:

These three problems were solved by the patented Delta T Dryer/MC control model that is based on the mathematically-derived model,

$$\mathbf{MC = K_1(\Delta T)^p - K_2/S^q,}$$

where (ΔT) is the temperature drop of hot air following contact with the wet product being dried, and (S) is the production rate, dryer speed, or evaporative load depending on which dryer-type is used. Solutions for the three main problems are described as follows:

1. The model invented a new “ inside-the-dryer” MC softsensor consisting of two temperature sensors and software that reduces the dead time and the exiting MC standard deviation by at least 30%, does not drift, and needs no re-calibration.

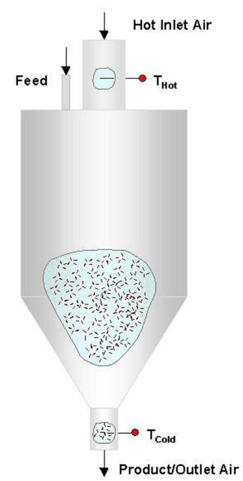
2. The model supplied a control algorithm that has the capability for adjusting the setpoint to maintain the target MC following changes in the evaporative load to the dryer.

3. The model supplied a new, simple, and inexpensive evaporative load softsensor that eliminates the need for expensive and maintenance-prone feedforward signals of the feed rate and the feed MC.

Delta T Application:

The Delta T applies to spray, belt, ring, rotary, flash and fluid-bed dryers. For spray, flash, rotary, and ring dryer application, the delta t parameter is obtained by continuously measuring the hot air inlet temperature (T_{hot}) and the exhaust temperature (T_{cold}), then calculating the difference ($T_{hot} - T_{cold}$) = (ΔT) for use by the model. Figure (1) depicts graphically the installation of temperature sensors to obtain the delta t parameter. Usually these sensors are already in place.

Figure (1) – Spray Dryer Delta T Measurement



The model process parameter (∆T) is directly proportional to the product MC exiting the dryer, the drying rate, the evaporative load to the dryer, and the humidity of the exhaust air. Additionally, five additional product properties, evaporative load, drying rate, relative humidity, water activity and surface temperature, may be sensed and controlled by the common parameter (∆T) simply by substitution of these product properties into the model. Descriptions of these unique softsensors may be obtained by visiting www.moisturecontrols.com

Comparison of MC Control Methods:

A. Exhaust Temperature Method:

One of the methods sometimes used for controlling product MC from spray dryers is to hold (T_{hot}) constant and adjust the heat rate to maintain an exhaust temperature (T_{cold}) setpoint that produces the target MC. However, if either the feed rate or feed density changes such that there is an increase in evaporative load to the dryer, the exhaust temperature (T_{cold}) will decrease below the setpoint (T_{cold}) value due to the extra heat removed from the air to evaporate the extra water. The difference in the setpoint value of (T_{cold}) and the new (T_{cold}) actual value is the error signal used to increase the heat a sufficient amount to drive (T_{cold}) back to the setpoint value. However, the old (T_{cold}) setpoint value will not achieve the target MC and must be re-calculated to achieve the target MC, but there is no precise method available for calculating the new setpoint value that will produce the target MC. Consequently, because it is not theoretically-based, this method does not allow optimization of the dryer with respect to production, quality, and energy conservation.

B. Feed Rate Method:

Some manufacturers use a MC control method that holds (T_{hot}) constant and maintains a constant (T_{cold}) by adjusting the feed rate. For example, if the density of the feed decreases, (T_{cold}) will decrease (more water but the same flow rate). The control action in this case would be to decrease the feed rate to bring (T_{cold}) back to the old setpoint. All this method accomplished is to assure that the evaporation rate is constant; it does not assure that the original target MC is maintained; therefore, due to the lack of a theoretical base, this method does not assure optimization of the dryer with respect to production, quality, and energy conservation. It does not address disturbances due to variations in feed rate or feed density.

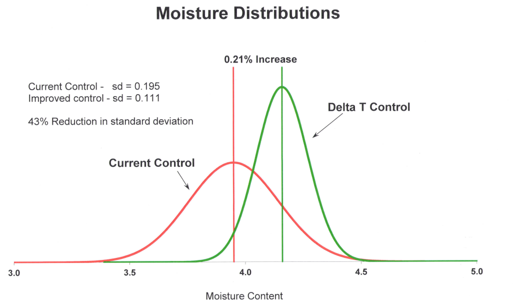
C. The Delta T MC Sensing and Control System:

Upon initial startup of a delta T MC sensing & control system, a value ($T_{hot} – T_{cold}$) is established that maintains the desired target MC. Thereafter, as evaporative load changes enter the dryer, they are immediately detected and the Delta T continuously re-calculates a new setpoint that maintains the target MC. The result is that the Delta T enjoys at least a 30% advantage over other methods in reducing the MC variation. This advantage translates into:

(1) increased production in terms of more water left in the product without exceeding the established upper limit;
(2) decreased unit energy consumption; and
(3) improved product quality.

Figure (2) below shows the results of applying Delta T MC control to whey dried in a FilterMatt dryer that reduced the MC variation by 43%, thus enabling the mean MC to be shifted by 0.21% without exceeding the established upper specification limit. This gave less than six months payout. Due to the large reduction in MC variation, there was additional room to shift the mean MC upward, thereby, increasing the 0.21%, but an inherent crystallization problem prevented such.

Figure (2) – Delta T MC Control of Whey from a Spray Dryer



The Delta T is Simple to Operate:

The Delta T is quite simple to operate and requires no re-calibration as required by conventional MC sensors. Additionally, the Delta T can be on line on the second day of a one-week startup period producing a simple payout of 3 – 4 months; whereas, model predictive control (MPC) requires 8 – 10 weeks for training, costs 6 – 7 times the price of a Delta T, pays out in 18 months, and it cannot reduce the variation below what can be accomplished by the Delta T. In addition, it must rely upon existing MC sensors that don't work. The Delta T is virtually fully automatic; therefore, it requires minimal operator input and allows them more time to concentrate on problems areas.

Summary & Conclusions:

Some advantages that enable the model-based Delta T Moisture Control System to achieve at least a 30% advantage over other moisture control systems are:

(1) Uses an exclusive, rugged, "inside-the-dryer" moisture sensor comprised of two temperature sensors and the software, thus it can operate in the harsh environment of a dryer and detect almost instantaneous changes in MC.

(2) An exclusive, proprietary method for handling evaporative load changes to the dryer.
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(3) After initial setup, cruise control startup can be used for new products by getting the MC on target using lab samples, then shifting to auto. The Delta T back-calculates a setpoint that maintains that target MC. If production changes are made, the Delta T adjusts to a new setpoint.

(4) The Delta T MC sensor never requires re-calibration as do conventional online MC sensors.

(5) Uses 100% of production rate as MC sample size.

(6) Minimal input is required by operators.

(7) Simple, easy to operate, not complicated, one-week startup, less expensive than model predictive control, and extremely effective in maintaining the target mc with at least 30% less mc variation.