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Adiabatic Dryer Control

The control of an adiabatic dryer often involves equations that incorporate wet bulb temperature. These equations help in regulating the drying process by taking into account the moisture content and the efficiency of the evaporation process. Here's a general framework for how wet bulb temperature can be integrated into the control of an adiabatic dryer:

1. Basic Concept

The drying process in an adiabatic dryer typically involves:

- **Dry Bulb Temperature (Td)**: The actual air temperature.
- **Wet Bulb Temperature (Tw)**: The temperature measured with a wet bulb thermometer, which reflects the moisture content in the air.
- **Relative Humidity (RH)**: The amount of moisture in the air compared to the maximum amount the air can hold at that temperature.

2. Key Equations

To control an adiabatic dryer, you often use the following equations:

a. Relative Humidity

Relative humidity can be calculated using the wet bulb temperature and the dry bulb temperature. The formula involves the psychrometric properties of air:

$RH=e(Twb)/e(Tdb)\times 100\%$

Where:

- e(Twb) is the saturation vapor pressure at the wet bulb temperature.
- e(Tdb) is the saturation vapor pressure at the dry bulb temperature.

The saturation vapor pressure can be approximated using the following formula:

$e(T)=611.2\exp(17.67T/(T+243.5))$

b. Moisture Removal Rate

The rate at which moisture is removed from the material can be influenced by the wet bulb temperature. This can be estimated using:

Moisture Removal Rate=Air Flow Rate×(Humidity Difference)

Where:

- **Air Flow Rate** is the volume of air passing through the dryer.
- **Humidity Difference** is the difference in moisture content between the air entering and leaving the dryer, which can be derived from the wet bulb temperatures.

c. Dryer Rate Equation

A simplified version of a control equation incorporating wet bulb temperature might be:

Drying Rate=k·(Tdb−Twb)·Air Flow Rate

Where:

- k is a constant that depends on the material and drying conditions.
- Tdb is the dry bulb temperature.
- Twb is the wet bulb temperature.

This equation reflects how the temperature difference (which relates to the evaporative capacity of the air) and airflow impact the drying rate.

3. Practical Implementation

In practice, the control of an adiabatic dryer involves:

1. **Monitoring**: Continuously measure the wet bulb and dry bulb temperatures.
2. **Adjusting**: Regulate the air temperature, humidity, and flow rate based on the measurements to maintain optimal drying conditions.
3. **Feedback Control**: Implement control systems that adjust parameters in real-time to achieve the desired drying rate and product quality.

In summary, while the specific control equations can vary depending on the design and requirements of the dryer, the wet bulb temperature plays a crucial role in understanding the moisture content and adjusting the drying process accordingly.

4. Detailed Drying Equation

According to the “Industrial Dryer Handbook” the wet bulb temperature is a key parameter in dryer control improvement. The following equation represents the correlation to product moisture and drying parameters:

X=K*LN((T1-Tw)/(T2-Tw)) where,

X= Product Moisture

K = is a dryer constant dependent upon product being dried and dryer design

T1 = Inlet Temperature

T2 = Outlet Temperature

Tw = Wet Bulb Temperature

In general, industrial dryers have not come equipped with wet bulb measurements due to reliability issues. Because of this, dryer control is typically conducted with the outlet dry bulb temperature controlling the inlet dry bulb temperature of the dryer.

The H2O sensor does work reliably in dryer exhaust gases so there is room for improved control in all dryers currently just using the dry bulb temperature control.

5. Wet Bulb Temperature Implementation

The best approach to implement the wet bulb temperature is to utilize H2O’s rental program where a sensor can be installed on a monthly basis and business case established. Data can be recorded with the following parameters:

Wet Bulb Temperature

Inlet Temperature

Outlet Temperature

Feed Rate

Air Flow

Manual Product Samples

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The data is then trended under current dryer control to show sensor repeatability and establish trends in the data. The main focus is to provide a tighter control on the product moisture with it being as close to the allowable moisture specification. This will maximize profitability as well as optimize energy efficiency. Once the optimal product moisture (X) is determined, it is then used to establish the "K" value by inputting the value in the product equation and using the corresponding temperatures at the same time the optimal value was achieved in the data.

Once the K value and optimal product moisture (X) are determined, the control of the dryer can use both as inputs to the following equation for controlling the inlet temperature (T1)

$$T1=(e^{(X/K)}*T2)-(e^{(X/K)}*Tw)+Tw$$

This equation will tighten control and improve over outlet temperature alone.