Real-Time Water Balance for Lime Hydrators

Using exhaust moisture to quantify evaporation, improve hydration control, monitor lime reactivity, and protect the baghouse

A hydrator exhaust humidity measurement can do more than indicate moisture. With exhaust flow and water-addition data, it can support a real-time mass balance around the hydration process.

Process Opportunity

Lime hydration is an exothermic reaction. A significant portion of the released energy is transferred into the evaporation of water. Measuring the water vapor leaving the hydrator therefore provides a direct process signal that can be used to quantify evaporation and potentially indicate changes in lime reactivity.

Hydrator water flow

Water + Quicklime → HYDRATOR → Hydrated Lime + Exhaust H_2O

Closing the Water Mass Balance

If exhaust gas flow is known - or is maintained at a reasonably constant rate - the H2O Optimization sensor measurement of exhaust water concentration can be converted to a water evaporation rate. The plant already knows the water being added to the hydrator. Together, these measurements provide the basis for a continuous water balance.

OVERALL WATER BALANCE

Water In = Water Out

EXPANDED HYDRATOR BALANCE

Water Added + Inlet Moisture = Exhaust Water + Reaction Water + Free Product Moisture

The key is separating chemically bound water from free moisture remaining with the hydrated product.

Stoichiometric hydration requirement

The hydration reaction is: CaO + H2O -> Ca(OH)2

Species	Molecular Weight
CaO	56.08
H2O	18.02

Species	Molecular Weight
$Ca(OH)_2$	74.09

Complete hydration theoretically consumes approximately **0.321 lb of water per lb of pure CaO.** For example, 10,000 lb/hr of available CaO requires approximately 3,210 lb/hr of water for the chemical reaction.

From % Volume H2O to lb/hr Evaporation

Because the sensor measures water directly as % volume H2O, the exhaust measurement can be combined with exhaust gas flow to calculate the actual amount of water leaving the hydrator.

> EXHAUST MOISTURE
>
> **Exhaust %vol H2O + Exhaust Gas Flow -> lb H2O/hr Leaving the Hydrator**

> NET EVAPORATION
>
> **Net Water Evaporated = Exhaust Water - Moisture Entering with Ventilation Air**

> ESTIMATED FREE PRODUCT MOISTURE
>
> **Free Product Water = Water Added - Reaction Water - Net Evaporated Water**
>
> Adjust for feed moisture and other known water sources or losses as required.

Potential Process Measurements

1. **Real-Time Mass Balance**
   Quantify how much added water is leaving in the exhaust versus being chemically consumed or remaining with the hydrated product.

2. **Lime Reactivity Indicator**
   Track evaporation rate as a potential indicator of changes in the exothermic hydration reaction and lime reactivity.

3. **Water Addition Optimization**
   Trend water addition, CaO feed, exhaust evaporation, and product quality to identify a more consistent operating window.

4. **Baghouse Condensation Protection**
   Use the same exhaust moisture measurement to calculate dewpoint and maintain appropriate temperature margin before the baghouse.

Suggested Data to Trend

The strongest evaluation would combine the exhaust moisture signal with existing plant measurements:

- Exhaust %vol H2O
- Exhaust gas flow
- Water addition rate
- Quicklime / available CaO feed rate
- Hydrator and exhaust temperature
- Ambient or inlet-air moisture
- Hydrated product moisture and/or quality data

Potential Control Metrics

Water Utilization	Reaction Water / Water Added
Evaporation Ratio	Net Water Evaporated / CaO Feed
Baghouse Margin	Exhaust Temperature - Exhaust Dewpoint

One measurement. Multiple process insights.

Measure the water leaving the hydrator to help close the mass balance, optimize water addition, monitor lime reactivity, and protect downstream equipment from condensation.