Lime / Limestone Wet Scrubbing System for Flue Gas Desulfurization

Background

Wet scrubbers are used in utilities, paper mills, and chemical plants to remove sulfur dioxide (SO_2) and other pollutants from gas streams. Undesirable pollutants are removed by contacting the gases with an aqueous solution or slurry containing a sorbent. The most common sorbents are lime ($Ca[OH]_2$) and limestone ($CaCO_3$). Emerson's Rosemount Analytical pH equipment is used to control the feed rate of these chemicals.

Process

After fly ash removal, the flue gas (seen in Figure 1) is bubbled through the scrubber, and the slurry is added from above.The lime or limestone reacts with the SO_2 in the flue gas to create insoluble calcium sulfite ($CaSO_3$) as in the equations below.

$$\text{Limestone: } CaCO_3^{(s)} + SO_2^{(g)} \rightarrow CaSO_3^{(s)} + CO_2^{(g)}$$

$$\text{Lime: } Ca(OH)_2^{(s)} + SO_2^{(g)} \rightarrow CaSO_3^{(s)} + H_2O^{(l)}$$

The resultant calcium sulfite can be further reacted with oxygen to produce gypsum (CaSO¬4·2[H2O]) by the following reaction.

$$CaSO_3^{(s)} + \tfrac{1}{2}O_2^{(g)} + 2H_2O^{(l)} \rightarrow CaSO_4 \cdot 2(H_2O)^{(s)}$$

The scrubbed gas is heated, to prevent condensation, and then discharged in a stack. Spent scrubbing liquids are sent to a clarifier, where much of the water is reused. Spent solids are removed in a heavy slurry to a settling pond. The water (with makeup fresh water, as needed) is returned to the scrubber. A pH sensor in a recirculating tank is used to control feed of solid lime or limestone.

Neither lime nor limestone dissolves well in water and therefore, both are pumped in slurry form to the scrubber tower. Lime slurry is more alkaline, having a pH of 12.5 while limestone slurry is roughly neutral. A lime based system will therefore add more lime when pH drops below 12 and a limestone based system will be controlled around 6. Unless one or the other is added, the SO_2 gas will quickly drive the pH acidic. The calcium compounds produced in scrubbers tend to accumulate in recirculation loops and can cause a buildup of scale. Scale on the spray nozzles affects the atomization of the water droplets and reduces the scrubbing efficiency. Scale on the return piping reduces flow rate and changes the thermal balance of the system. The tendency to scale is limited by additives such as chelating agents and phosphates, but these additives are generally only effective at higher pH levels. pH control is necessary to forestall the start of scaling, as it is much easier to prevent scaling than to remove it.

Temperature is also monitored because the solubilities of lime, limestone, and gypsum are unusual in that they decrease with increasing temperature. Since neutralizing reactions produce heat, scaling problems are doubly influenced when the scrubber has a heavy load.

Instrumentation

The 3300HT/3400HT PERpH-X ™1 high performance sensors are recommended for measurement in harsh scrubbing process applications. Their recessed AccuGlass™2 glass electrodes resist abrasion or cracking due to the scouring action of suspended solids and the large-surface area Teflon liquid junctions resist fouling. Should the sensor ever become coated or fouled, the liquid junction may be replaced and the electrolyte replenished. If a disposable sensor is preferred, the 396 TUpH™3 offers similar fouling resistance but cannot be rebuilt. Both sensors are compatible with the complete line of Emerson's Rosemount Analytical pH analyzers. Line-powered options include the 1056 which offers dual inputs and a large, bright display. The 1056 features extensive troubleshooting and diagnostic help in plain language, reducing operator training requirements.

[1] PERpH-X is a trademark of Rosemount Analytical.
[2] AccuGlass is a trademark of Rosemount Analytical.
[3] TUpH is a trademark of Rosemount Analytical.

Instrumentation

3300HT/3400HT PERpH-X pH/ORP Sensor

- Long lasting, rebuildable reference for lowest total cost of ownership.
- High temperature design resists performance degradation due to temperature cycling.
- Rugged, versatile design available in a variety of installation and material configurations.
- Customizable reference fill solutions resist scaling or poisoning.

1056 Dual Input Intelligent Analyzer

- Dual configurable inputs and outputs.
- Large, bright LCD display.
- Intuitive menus with advanced diagnostics.
- 4 alarms relays with timers.
- Optional HART®[4] or Profibus®[5] DP.
- Polycarbonate type 4X (IP65) enclosure.

396P/396R TUpH pH/ORP Sensor

- Patented polypropylene reference junction and patented helical pathway mean longer sensor life in process solutions containing heavy solids.
- Disposable one-piece construction is convenient and economical where minimal troubleshooting and maintenance downtime are of prime importance.
- Patented helical pathway prevents sulfide poisoning.
- Suitable for flow-through and submersion applications.

1066 pH/ORP

- Two-wire transmitter.
- Optional HART or FOUNDATION®[6] fieldbus.
- Polycarbonate type 4X (IP65) enclosure.

[4] HART is a registered trademark of the Hart foundation
[5] Profibus is a registered trademark of Profibus & Profinet International
[6] FOUNDATION Fieldbus is a registered trademark of the Fieldbus Foundation

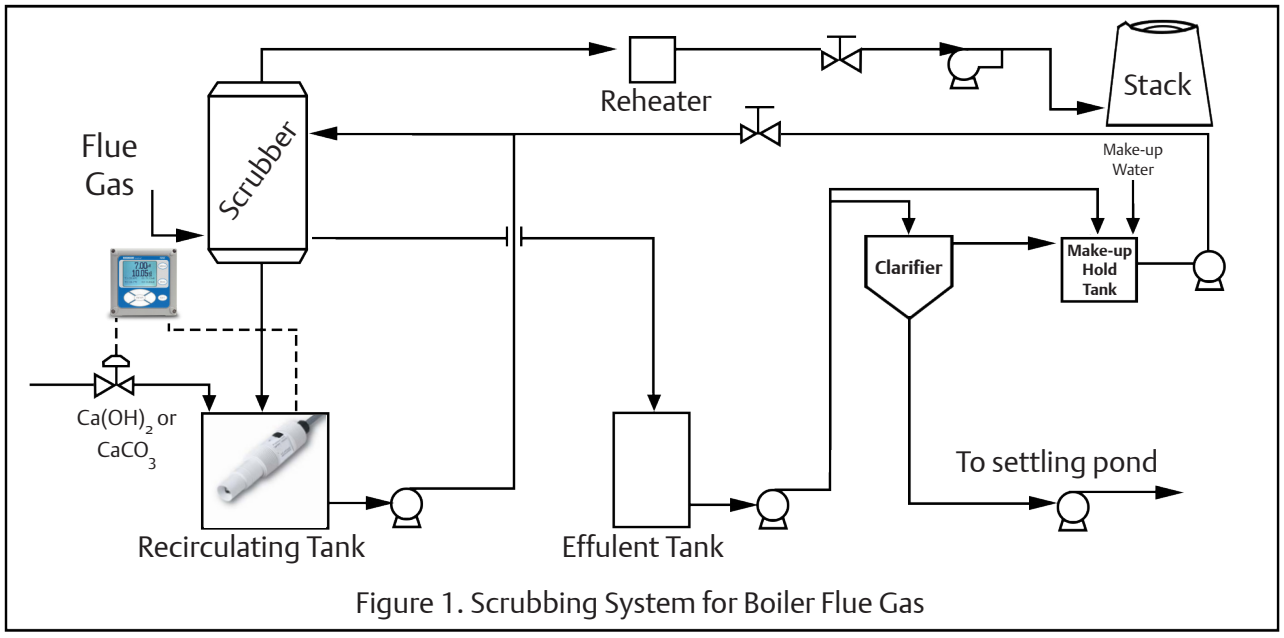

Figure 1. Scrubbing System for Boiler Flue Gas

Emerson Process Management
2400 Barranca Parkway
Irvine, CA 92606
USA
Toll Free + 800 854 8257
T + 949 757 8500
F + 949 474 7250
Liquid.CSC@Emerson.com

ROSEMOUNT™

EMERSON™
Process Management