Cooling water leak into boiler feed water

Steam generating boilers are commonly used in sulfuric acid plants, for process gas cooling, waste heat recovery and steam usage at various locations. The steam—typically in the 450 to 900 psig range—drives turbines, and upon pressure reduction meets other heating needs in the plant. Upon extracting the useful energy, most of the steam is condensed and returned as feed water to the boiler. As with any industrial boiler, the feed water must be kept clean with low mineral content to avoid boiler tube and turbine rotor deposits.

In one acid plant, a cooling water leak occurred in a steam condenser for the turbine generator. As the steam-side of the condenser is operated in almost full vacuum, and the cooling water side at approximately 40 psig, the leak path was cooling water into steam condensate. This was a slow leak, and continued for months without proper action. As cooling water is full of minerals, at approximately seven times the raw water concentration, even a small leak can overwhelm the pristine steam condensate system. The result was a series of boiler tube ruptures caused by overheated tubes, stemming from water-side hardness deposits. These boiler tube ruptures caused a lot of plant outages, and to minimize further down time, the plant employed drastic short term measures. This included an inhibited acid wash of the water tube boiler, followed by hydroblast cleaning of each tube, to remove the majority of the hardness deposits. The condenser was also repaired to prevent further leaks and damage. The short-term repair required two weeks of unplanned outage, and allowed the plant to operate until a scheduled turnaround when more permanent maintenance could be done. The boiler and condenser were subsequently re-tubed.

In another acid plant, a similar cooling water leak occurred at the turbine generator condenser, and again continued for months without proper action. In this case, the boiler tubes were not damaged, but minerals carried over to steam turbines for the main gas blower and the electrical generator. Both turbine rotors were coated with heavy mineral deposits, knocking them out of balance. The plant was shut down for a week to remove, clean and repair the main gas blower rotor. The turbine generator was shut down for three weeks for rotor maintenance. The condenser leak was temporarily repaired. This allowed the plant to operate until a scheduled turnaround when the condenser could be re-tubed.

Lesson learned: Take immediate action upon detection of conductivity or hardness increase in the boiler feed water system. Fix cooling water leaks as soon as possible.

Leaking converter isolation valves

Many acid plant converter systems are equipped with a startup preheater system to heat the converter beds prior to introducing SO_2, known as a "cold startup." This typically consists of a fuel gas or oil combustion furnace system, a gas heat exchanger and associated ducting with isolation valves to the converter beds. The isolation valves need to perform well, from a wide open position during heat up, to modulation during the introduction of SO_2, to a completely closed "tight shut off" position during normal operation. In some cases, this valve is exposed to a high process gas temperature of about 1,000 degrees F during the heat up phase, which makes the functionality of the valve very challenging.

In some configurations of double absorption plants, tight shut off during normal operation is especially critical for the isolation valve to the final converter bed. This isolation valve keeps a strong 10 percent SO_2 gas on the high pressure side from leaking into the low strength 0.5 percent SO_2 gas on the low pressure side, with a differential pressure of 150 inches of water column. As the final bed typically converts 97 percent of the 0.5 percent SO_2, emitting 0.015 percent (150 ppm) SO_2 to the atmosphere, a small leak in this isolation valve can significantly impact the SO_2 emission. Coupled with a severe mechanical service during heat up, distortion and binding of the shaft/bearing can become a significant issue, if the valve is not constructed robustly.

Such was the case for a 3/1 double absorption acid plant, until the proper valve and maintenance method were found after several trials. In some startups, the isolation valves became so distorted, bound and inoperable that slip blinds needed installation and removal at hot condition, a nasty job for the maintenance workers. This plant corrected the problem with a set of heavy duty butterfly isolation valves of stainless steel construction, including a warehouse spare. (A knife-gate valve, another widely accepted option, was considered, but was found more costly in this application.) It was also found necessary to lubricate and stroke the valve routinely, to keep the shaft and bearing from binding in this severe service.

Lesson learned: Choose the correct robust valve, and maintain it properly with routine lubing and stroking. Always keep a warehouse spare.

Charring of tail gas scrubber packing

Many acid plants are equipped with a tail gas scrubber to meet SO_2 emission requirements mandated by various agencies including the EPA, state and local air quality districts. Many of these scrubbers utilize aqueous alkali reagents such as caustic, soda ash or ammonia, with the circulating alkali sulfite/bisulfite liquor pH ranging from acidic to basic. The scrubbers are therefore constructed with plastic and stainless steel to withstand corrosion. If the scrubber utilizes packed beds, polypropylene packing has been the top choice to withstand corrosion at a relatively low cost.

Under normal operating conditions, the polypropylene packing performs well in withstanding the corrosive nature of SO_2 scrubbing with alkali sulfite and bisulfite liquor. It is susceptible, however, to an abnormal condition of a sulfonation reaction if a large quantity of SO_3 is present, especially if the packing runs dry.

A single absorption acid plant experienced such an incident. This plant was equipped with a steam-turbine-driven main gas blower, a SO_3 absorbing tower circulating strong acid with a motor driven pump and a SO_2 caustic scrubber circulating sodium sulfite/bisulfite liquor with motor driven pumps. A power outage caused the absorbing tower and scrubber circulating pumps to cut out. The steam-driven main gas blower, however, kept running, directing unabsorbed SO_3 gas to the scrubber for about 10 minutes. Upon return of power, the circulating pumps were restarted, and the operators noticed an abnormal pH in the scrubber liquor. Upon shut down and inspection, the polypropylene packing was found charred by the SO_3 with dry packing. This caused a plant outage to replace the damaged packing.

Upon investigation, it was found the main gas blower was not properly interlocked to shut down on power outage. Operators were not trained about the effect of SO_3 gas in the scrubber.

To prevent further incidents, operator training was updated and the main gas blower was interlocked on power outage. Additional interlocks were installed to shut down the main gas blower on low absorbing tower circulation and high scrubber temperature.

Lesson learned: Conduct a proper process hazards analysis, incorporate safety interlocks and update operator training. ❑