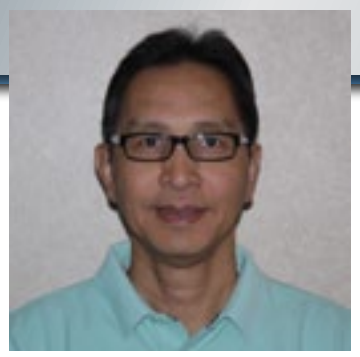

Case histories from the sulfuric acid industry

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Cart before the horse

Gas-gas exchangers upstream of the interpass and final absorption towers in double contact, double absorption metallurgical and spent acid regeneration plants are prone to sulfate blockage in the SO_2 and SO_3 sides. The attendant loss in heat transfer efficiency increases the gas temperature into the absorber towers, thereby increasing mist formation as well as increasing the load to the acid coolers. In addition, it also decreases the temperature into the catalyst bed downstream. The increase in pressure drop due to the sulfate blockage not only causes a reduction in production capacity, but also can breach the divider plate between catalyst beds. The breach will cause SO_3 to bypass the absorbing tower. All these will result in an increase in stack SO_2 and acid mist emissions.

The sulfate blockage is normally the symptom of poor equipment design, improper operation and/or non-maintenance of the pieces of equipment upstream. Fig. 1 shows sulfate blockage in the shell side of a cold reheat exchanger with stainless steel tubes. The SO_2 gas passages are almost entirely blocked. Fig. 2 shows sulfate blockage in the tube side of a cold reheat exchanger. The inner 10 rows of tubes are entirely blocked for SO_3 gas passage.

Fig. 1: Sulfate blockage on shell side.

Fig. 2: Sulfate blockage on tube side.

To solve the blockage problem, some plants choose to correct the symptom rather than address the root cause. The exchanger is replaced with some modifications when all the sulfate removal techniques in their arsenal have been exhausted. Reversing the SO_3 flow from the traditional downward flow inside tubes and changing the material of construction to stainless steel are some of the techniques used. All these have proved to be inadequate and after less than three years in operation, the plant is back to square one. Cases in point are shown in Fig. 3 where SO_2 gas was switched with the traditional upward flow in the shell side to downward flow inside the tubes, and in Fig. 4 where SO_3 gas flow was reversed from the traditional downward flow inside the tubes to upward flow inside the tubes. All these modifications were in vain.

Fig. 3: Cold exchanger with SO_2 flowing down inside tubes.

Fig. 4: Cold exchanger with SO_3 flowing up inside tubes.

Fig. 5: Divider plate between beds 3 and 4.

Fig. 5 shows a photo of the divider plate between beds three and four. A portion of the circumferential weld on the sidewall cracked due to the high-pressure drop in the cold reheat exchanger.

Lesson learned

Do not put the cart before the horse! Correct the root cause of the problem first before replacing the exchanger. Replacement designs should be given due diligence by an independent consultant who has knowledge and experience in the operation and maintenance of the equipment.

Taken for granted

Weather protection or cladding for thermal insulation on hot pieces of equipment, ducting and piping is the fixed asset that is widely taken for granted in most acid plants. Once installed, it is forgotten. And when it gets damaged from people stepping on it, blown by the wind or other causes, it rarely gets the attention like the other pieces of equipment in the plant do. Cladding is important in that it protects the thermal insulation from the elements, preventing water ingress. Water is detrimental to any thermal insulation system. With the proper weatherproof construction design to accommodate expansion and contraction movements and with the necessary flashings and seals, ingress of water is eliminated.

However, this is not always the case, as shown in Fig. 6 where the cladding on the roof of a converter has been badly deformed due to improper design, not accounting for the expansion/contraction of the cladding. In this particular case, the water that entered through the gaps ran down the sidewall of the converter and cooled the metal, causing condensation of acid on the catalyst along the perimeter of the sidewall. Fig. 7 shows the catalyst damage caused by acid condensation.

Fig. 6: Cladding on roof of converter.

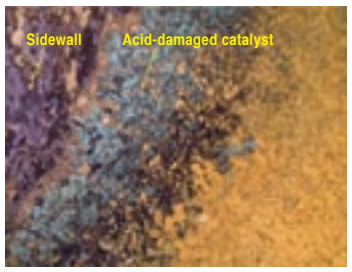

Fig. 7: Catalyst damage along sidewall perimeter.

Fig. 8: Water ingress through the cladding of an expansion joint.

Fig. 8 shows evidence of water ingress through the cladding of an expansion joint due to inadequate flashing and sealing. The sudden cooling of the hot metal badly deformed the convolution and created cracks in the metal, as shown in Fig. 9.

Fig. 9: Badly deformed and cracked expansion joint convolution.

Lesson learned

Never take for granted the cladding for thermal insulation of hot pieces of equipment, ducting and piping. Cladding, like any other acid plant equipment, should be given regular inspections. When damage is found, it should be repaired at the most opportune time. Design of the cladding should not rest entirely on the insulation contractor. Someone with know-how and experience on how the equipment operates should review the design.

Bridging the gap

Expansion joints are piping components that are designed to accommodate thermal and mechanical changes in the piping system. They are usually made up of a series of convolutions forming a bellow, which is flexible enough to compensate for axial, lateral and/or angular movements.

Expansion joints are often installed where expansion loops cannot be made due to limited space. If properly designed, installed and maintained, piping expansion joints should last a long time. Their use, however, in sulfuric acid piping should only be the last resort as they are the weak link in the piping system.

Fig. 10 shows an expansion joint for a product-acid piping that is incorrectly applied. Based on the inspection of the piping run and considering the operating temperature of the product acid, the need for an expansion joint is not required. This particular expansion joint, however, was installed to bridge the gap from misalignment caused by poor pipefitting. The expansion joint is permanently deformed and poses a safety hazard to everyone in the area.

Fig. 10: Expansion joint in a ductile iron piping system for product acid in the cold position.

Lesson learned

Misapplication of expansion joints can have serious consequences to the health and safety of everyone in the area. Always

consult with a piping stress engineer for the proper type and application of expansion joints prior to installation.

In a hurry to startup

Maintenance turnarounds in acid plants can be very stressful. There are pressures coming from everywhere: pressure to finish the work on time, pressure to keep the cost on budget, pressure to get back on line as quickly as possible. So when an opportunity to save time comes around, management often jumps on it. Such is the case for a spent acid regeneration plant. Operations decided to get a jump on starting up the plant while work progressed in the acid circulation of the brick-lined final absorber tower. This particular acid plant is a 3+1 double-contact, double-absorption unit with the catalyst beds in stand-alone vessels. The 4th catalyst bed is equipped with its own preheating system. Preheating started with no acid circulation in the final tower. Towards the end of the preheating cycle, an alarm went off in the stack monitoring system and a visible plume was noticed coming out of the stack. During preheating, the SO_2/SO_3 that was trapped in the catalyst during the cool down process prior to the turnaround was released when the catalyst started to liquefy. Without acid circulating in the final absorbing tower, the SO_3 just went through the packed section unabsorbed by the acid that was held up in the packing. In addition to creating stack emissions, putting hot gas in a brick-lined acid tower without the cooling effect of acid circulation is very risky. There is very high probability of collapsing the packing support and damaging the brick lining and packing at the bottom section when acid circulation is turned on due to thermal shock.

Lesson learned

During preheating of the converter beds, ensure that the absorber towers have acid circulation in them to absorb SO_3 that may be released when the catalyst starts to liquefy. Also, this will eliminate the possibility of damaging or collapsing the packing support.

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Roberts continues to expand offerings

WINTERVILLE, N.C.—Roberts, a fully integrated engineering, fabrication, construction and plant maintenance company, continues to impress customers in the sulfuric acid industry with its quick response and quality workmanship. Recent projects have allowed several of Roberts clients to expand product offerings, improve plant processes and extend the life of their equipment.

Roberts recently worked on one of Mosaic's largest projects to date.

Mosaic, featured in this edition, relied on Roberts' extensive experience in the industry to provide the necessary work for several projects. The first was a new MECS Heat Recovery System™ (HRS). Mosaic also tapped Roberts to provide site prep, concrete and pilings for their Micro Essentials™ project, one of the largest projects Mosaic has undertaken.

Roberts' quick turnaround at Rentech Nitrogen, disconnecting an old acid converter and installing a new, larger converter and associated ducting in their sulfuric acid plant, will allow the company many years of continued operation. Improved heat recovery and less downtime from a system that operates at peak performance are just some of the benefits of this project.

A recent job for Rentech Nitrogen provided improved heat recovery and less downtime.

The sulfuric acid industry continues to rely on Roberts for its multitude of capabilities and vast knowledge. As a long-time service provider, Roberts has proven time and time again to be reliable, efficient and responsive. This leads customers to return for a variety of projects, including new project design, project management, plant maintenance services and repairs, as well as shutdowns, turnarounds and fast track emergency response.

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