

Three important lessons for sulfuric acid plant design

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1. Not all dry towers are created equal

Proper dry tower design, maintenance, and operation impact overall plant performance and economics. Run your dry tower too hard, and you can end up with mist carryover into the blower and excessive acid carryover in the plant leading to corrosion, crusting of catalyst beds, and drip acid. Don't run your dry tower hard enough, and risk low production rates and missed opportunities to make more product.

Faced with these trade-offs, several acid plants have recently found creative ways of operating their dry towers with custom-engineered Brink® Mist Eliminators by MECS to achieve acceptable mist removal while simultaneously reducing pressure drop, resulting in more operating margin.

Reducing the dry tower mist eliminator pressure drop results in more pressure margin for fouling by sulfates and dirt when present in the process. Thus, the extra fouling margin helps reduce maintenance and provides longer uninterrupted plant production runs.

Reducing pressure drop also results in either higher production rates or reduced energy costs. When plant production rate is blower limited, extra production capacity can be estimated based on a reduction in pressure drop for an individual plant equipment item. With new dry tower mist eliminators, pressure drop can be reduced by about 3.5 inches wc.

When a new equipment item results in lower pressure drop, this in effect creates a new total plant equipment gas resistance curve. The intersection of the blower curve with the new total equipment gas resistance curve can be determined and compared to original design rate, assuming production rate and gas flow rate are roughly proportional.

Fig. 1 shows a typical blower curve. Superimposed are typical total equipment gas resistance curves. Design blower static pressure and flow rate are designated as P_0 and R_0 respectively. This point is at the intersection of the blower curve and the original total equipment gas resistance curve (solid red and blue curves). When the pressure drop of an equipment item is reduced, the total equipment gas resistance curve shifts downwards as shown (dashed blue curve). A new equilibrium point is achieved where this curve intersects the blower curve, e.g., at the point designated by P and R.

For a 3.5-inch wc reduction in pressure drop, a 2,500 STPD plant could increase sulfuric acid production by about 18 STPD. Assuming there is margin in the steaming equipment, high pressure steam production would also go up proportionately, less some increased steam to power the blower turbine drive.

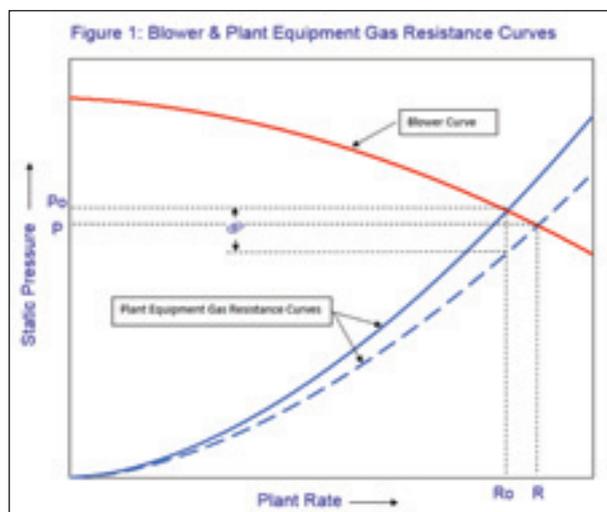


Fig. 1: Blower and plant equipment gas resistance curves.

If the plant has excess capacity, then the value of reducing operating pressure drop is related to reducing the cost of operating the plant blower. In the case of an electric drive, the calculation is straightforward based on the value of reducing electrical usage. If the blower is steam driven, however, a reduction in operating pressure drop relates to the value of the high-pressure steam savings that would normally be used to add incremental pressure to the blower. The value of the high-pressure steam depends on whether there is a turbo-generator on site with excess capacity to produce incremental electric power. In general, when the plant is blower limited, reducing pressure drop for an individual plant equipment item is more valuable as it relates to increased plant production. However, even when the plant is not blower limited, when for example fouling of dry tower mist eliminator affects the plant service cycle, adding more operating margin by reducing pressure drop results in lower maintenance and sustained production.

Lesson learned

By using lower pressure drop dry tower mist eliminators with less fouling tendency, significant improvement in plant performance was realized. Thus, it is true that not all dry towers are created equal. However, it is true that custom-engineered solutions for unique operational challenges can result in a scenario where the plant owners and operators can have their cake and eat it too: acceptable tower performance and mist removal AND a choice of higher operating margin via lower pressure drop with energy savings or higher capacity with higher steam rate.

2. Passing gas

In an interpass absorption plant, it is important to have a gas-tight division plate between converter passes in order to obtain maximum conversion. In most situations, this is achieved by utilizing a fully welded division plate.

A customer who reported difficulties in reaching design conversion noted the presence of SO_3 gas below the division plate following the interpass absorption tower (IPAT). Testing indicated that the SO_3 was not the result of poor absorption in the IPAT or leaks in the gas/gas heat exchangers. However, a review of the converter drawings revealed that the division plate was a bolted and gasketed connection. Unfortunately, because of the size, a single ring gasket was not possible and, in addition, few gasket materials were suitable for the high temperatures involved. Division plate leaks were therefore unavoidable.

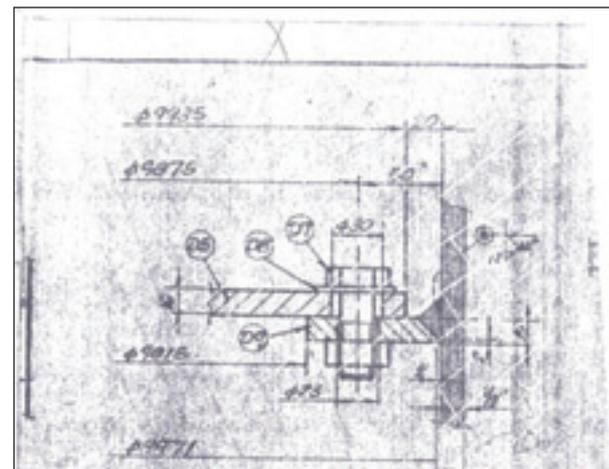
Lesson learned

Although the bolted connection looks like it should be fairly gas tight, the leakage was higher than could be tolerated. Only 99.4 percent conversion could be achieved in this sulfur burning plant at 9.6 percent SO_2 . By welding a rolled angle over the bolted joint, the problem was solved and conversion increased to 99.7 percent at 10.5 percent SO_2 .

3. Impaired judgment

There are catalyst analytical services (such as PeGASyS) that measure the conversion after each pass and back-calculate the catalyst activity, based on the measured inlet temperature. While this is invaluable for judging the health of the catalyst prior to a shutdown, the reported catalyst activity is actually a sum of numerous effects. Thus, it is not unusual to find catalyst samples sent in for activity testing returning higher levels than reported by the analytical services.

So, what other factors have an impact on apparent catalyst



Original division plate connection detail.



Modifying the division plate seal.

activity? The two most common are temperature homogeneity and gas distribution.

Temperature homogeneity is a function of mixing bypass gas before entering the converter. There are two tip-offs that temperature is not homogenous. First, the outlet duct temperature indicates a higher temperature than the bed (normally the duct temperature is 10 degrees C to 15 degrees C lower than the bed temperature) and second, the outlet bed temperature is higher than the calculated equilibrium value.

In Fig. 2, the measured outlet temperatures from Pass 2 are 525 degrees C and 528 degrees C, for the bed and duct respectively. Note that the Pass 2 outlet duct temperature is 3 degrees C hotter than the bed temperature and both the bed and duct temperatures are higher than the 523 degrees

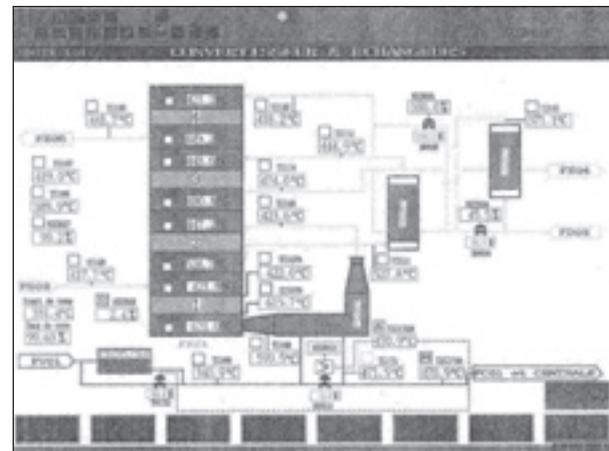


Fig. 2: Pass 2 outlet duct temperature higher than bed temperature.

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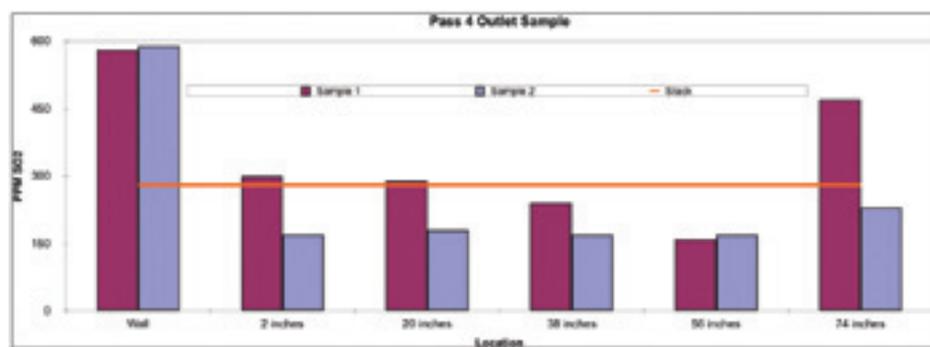
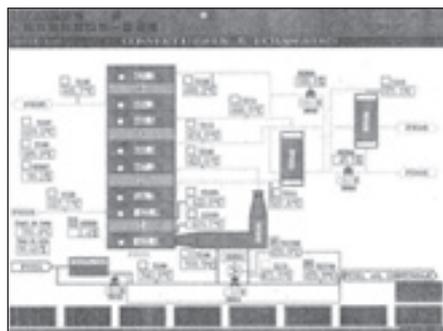


Fig 3: Pass 4 outlet sample graph.

C calculated equilibrium temperature. This problem was traced back to a fabrication error in the superheater that allowed internal bypassing. Once repaired, the superheater temperature and conversion both improved.

Gas distribution problems are much more difficult to detect because rarely is there more than one thermocouple installed



in any bed at the inlet or outlet. And, even when there are several thermocouples, they may not be in the area where there is low or high gas flow.

When recently faced with a suspected gas distribution problem, some new troubleshooting techniques were developed that allowed for gas sampling inside the converter. Samples were extracted from inside the converter at various distances, by inserting a probe through a packing gland.

The graph in Fig. 3 shows the data. The horizontal line represents the SO_2 in the stack and the bars are the analysis of the samples at various distances from the wall. As expected, there is a wall effect, but the magnitude at this plant is much higher than most (wall readings are typically 10 percent to 15 percent higher than the bulk). What is



Converter sampling probe.

more interesting is the upward trend at the 74-inch mark, which is about one quarter of the way across the converter.

In this particular case, gas distribution is the suspected cause. CFD modeling showed that the inlet transition was too abrupt and the absence of directional vanes in the nozzle did not allow for even gas distribution across the whole bed. For reference, the samples were taken at a 90 degree angle from the inlet/outlet nozzles.

Lessons learned

To get good conversion, you not only need to have good catalyst, but you also need to have homogeneous temperatures and even gas distribution. This ensures all areas of the catalyst are working at their highest potential. This is especially critical for converters

with low velocities, shallow beds and/or bed pressure drops below 3 inches wc. In these cases, external factors can have a significant impact on conversion.

On the flip side of the coin, debottlenecked plants with deep beds and high velocities tend to have better correlation between field analytical activity tests and catalyst sample activity analysis. Higher-pressure drop improves gas distribution through the bed.

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