CECO Filters

DE-BOTTLENECKING SULFURIC ACID PLANTS THROUGH INNOVATIVE MIST ELIMINATOR IMPROVEMENTS

By Ramachandran Gopalakrishnan CECO Filters, India and Roger Fernandez CECO Filters, USA

De-bottlenecking Sulfuric Acid Plants through Innovative Mist Eliminator Improvements

ABSTRACT
De-bottlenecking and capacity increases in Sulfuric Acid plants often require improvements in high efficiency mist elimination. De-bottlenecking requires strict attention to the specific plant process parameters and the relevant filter design limits. As well as increasing plant capacity, the modification discussed here can also reduce pressure drop and extend the time between filter washing or change-outs.

Innovative approaches to Fiber Bed filter design; manufacture and installation are illustrated through case histories. In these cases, plants have achieved reduced emissions and improved fiber bed filter life cycles.

In the Sulfuric Acid manufacturing process, Fiber Bed filters (which will also be referred to in this paper as 'candle filters', 'Fiber Bed mist eliminators' and 'filter elements') are utilized on the downstream side of sulfuric acid absorption towers for the collection and removal of fine Sulfuric Acid mist from the effluent gas stream. This paper will focus on enhancements of the Fiber Bed filter performance in order to obtain the highest levels of overall system performance.

A well-designed Sulfuric Acid plant will operate properly when operating parameters are held within design conditions. Most Sulfuric Acid plants, however, are under pressure to produce as much Sulfuric Acid as they possibly can. In order to achieve increased capacity, it is often necessary to make modifications to some equipment and exceed design conditions for other equipment. Significant effort and capital investment are expended in order to increase acid production. This increased production is often accompanied by increases in total through-put for the plant. This increase in through-put often affects the performance of mist eliminators in the Drying Tower and Absorption Towers. The results can include excessive pressure drop, equipment damage from acid carry-over, visible emissions from stack discharge and acid precipitation raining from stacks.

While we are talking about mist eliminators (ME's) and their applications in H_2SO_4 plants, since mist eliminator design alone is only one part of the tower performance, it may be appropriate to review installation/maintenance and operational problems related to ME performance. We will summarize some fairly basic, but very important factors, since at one time or another each of these items has contributed to failures, shutdowns, equipment damage and reduced acid production.

One of the first considerations is the installation of the candles (mist eliminators). To begin with, it is very important to ensure that the filters are clean, in good condition and that all packaging such as plastic wrapping and flange covers have been removed. When ME candles are installed, proper gasketing is critical on both standing and hanging filter configurations. In most cases full face gaskets are preferred as the most easily installed. It is possible to use expanded PTFE rope gasketing if it is very carefully and properly tightened.

Once the candles are installed and bolted in place, seal pots for individual candles (hanging candles), or seal pots for the tubesheet (standing candles) should be cleaned and filled before re-starting from a major turnaround. One mistake is to send a maintenance technician with a water hose into the ME housing in an effort to 'clean off' filter surfaces. Massive water force can punch a hole in the media, plus weak acid will damage the metal in the candles and tubesheet — and yes, it has been done. Also, proper inspection for holes in the floor (or tubesheet), flange welds, or inspection for leaks in seal leg pipes and pots, should prevent gas by-passing which, in turn, can cause re-entrainment of collected acid.

It is extremely important to note here that a very minimal amount of gas bypass, such as only a very small percentage of total gas flow, can re-entrain a large quantity of collected acid resulting in the generation of acid mist which can have significant negative impact on overall Fiber Bed filter performance. This re-entrainment phenomenon, from extremely small incidences of gas bypass, will result in adverse effects on downstream equipment, poor stack stick tests and increased emission rates which are seemingly out of proportion with the actual amount of gas being by-passed.

Tower performance and mist formation can be affected by many variables, i.e.: acid temperature, acid strength, gas inlet temperature, sulfur quality, and steam leaks from boilers, economizers, superheaters or sulfur guns. Changes in these variables can result in the ME's being operated outside their acceptable operating range causing poor performance through reduced efficiency, high pressure drop or re-entrainment.

The performance of the acid distributor, and the piping supplying it can not be overlooked; as well as the pressure drop in the tower packing, potential flooding conditions, etc. Inadequate acid flow for process conditions, inadequate acid cooling system capacity and fouling can also affect tower performance and ME conditions. All connections need to be checked for tightness to avoid leaks. It is recommended to take advantage of where site glasses have been provided to observe the internal operation of vessels.

Sulfur sublimation in burners will almost always require IPAT mist eliminator replacement, since ME's will also act as excellent particulate filters which will capture solid sulfur particles.

CECO Filters and other knowledgeable Sulfuric Acid mist eliminator suppliers can help evaluate the total performance and contribute to the problem solving effort whenever excessive downstream mist is encountered in either drying, interpass absorbing, or final absorbing tower applications.

In looking at the requirements for mist elimination in expansion of capacity, one must evaluate a number of factors, such as inlet liquid loading, velocities, and efficiency requirements. Particularly when dealing with plant capacity expansion care must be taken to address issues that could result in inadequate mist removal efficiency or acid re-entrainment after the mist eliminator.

CECO Filters has a number of weapons in our arsenal to attack the issues that occur in debottlenecking/expanded capacity projects. We bring a wealth of in-house experience in both mist eliminator design as well as Sulfuric Acid plant design and operation. We combine this experience with unique product designs such as the Graded Bed™ and TWIN-PAK® filter to provide mist eliminators with low pressure drop and high efficiency required in the upgraded Drying and Absorption Towers.

A "Graded Bed™" is a candle filter with a media bed that is constructed of multiple layers of different types of media, each with a specifically desirable quality. In the CECO Filters "Graded Bed™", we employ two to three types of media per bed. Of course, we use the time-tested rope-wound media for high collection efficiency of the sub-micron droplets. But, what sets CECO Filters' "Graded Bed™" apart from other Fiber Beds is that we employ an initial (upstream) layer of blanket media for uniform gas distribution and solid particle depth loading, and we are able to apply the rope media, on the downstream side, with a much higher density because it is applied after the blanket media. The Graded Bed™ allows CECO Filters to customize the pressure drop and increase removal efficiency performance of the candle mist eliminators to the specifics required by the de-bottlenecking project.

Another innovation is CECO's TWIN-PAK® candles which take advantage of the unused space inside the annular space of the filter element to increase the available surface area of the Fiber Bed element. This is particularly important where it is necessary to incorporate additional ME surface area inside an existing absorption vessel. In the case of an expansion, the existing unit can be retrofitted to accommodate up to 60% more gas flow with the same mist eliminator vessel. TWIN-PAK® filters and be installed in the same bolt hole pattern and utilize the same footprint as the original conventional fiber bed. This leads to improvement in through-put and pressure drop for the tower.

CASE STUDIES

In order to illustrate the application of these system performance improvement principles, following are descriptions of case studies where improvement of Fiber Bed performance has resulted in increased plant capacity or improved overall system operation.

Customer A

This customer has three large Sulfuric Acid Plants at a single site. All of them had Fiber Bed Mist Eliminators Filters supplied by the original process OEM. All used hanging type filter configurations.

They had been experiencing carryover of acid in all the three plants whenever they were running at or near capacity and all their experiments with acid distributors and other tower internal components did not solve their problem, and thus they narrowed down their focus to potential problems with the candle filter Mist Eliminators.

Normally only two things can happen with Mist Eliminators:

1) High pressure drop can occur when the filter media becomes plugged with solids or other matter and
2) Low pressure drop can occur when there is gas bypass caused by gaps along the length of the Candle Filter or shrinking of the media this can result in a gas bypass and re-entrainment condition commonly called worm holes.

In the case of this customer, the problem could be attributed to low pressure drop due to gas bypass and thereby carryover affecting the cold Re-heat exchanger after the Intermediate Absorption Tower and thus discharge of excessive emissions to the atmosphere after the Final Tower.

CECO Filters interacted with the Customer over several months, examined the data furnished after intense study of the Customer's problems, and suggested a design using Graded Bed principles which improved drainage of sulfuric acid. This recommended design which utilized graded fiber in a combination of roving and blanket media, enhanced performance to improve the capture and removal of aerosols and acid mist from the gas stream. These GRADED BED™ filter elements, which were designed especially to improve drainage of collected acid.

Customer B

This customer has two 3,500 TPD Sulfuric Acid Plants. Both plants have had Brownian Diffusion Eliminators installed at during the initial plant construction. Unfortunately, the plants had a history of inadequate equipment maintenance. There was significant mist carry-over from the exit of the FAT's and the site was under constant scrutiny from the local environmental authorities. This ended up in the plants being shut down for failure to meet the local regulatory environmental requirements.

After the new owners took over, they contracted for a consultant to sort out all the deficiencies in the plants who, in turn, solicited input from a number of equipment vendors. This resulted in a project in which the existing Candle Filters were replaced by CECO Filters in the FAT and by others in the IAT and both streams were then commissioned and are now running satisfactorily without any carryover problems. The plant now meets the required pressure drop and collection efficiency requirements.

The Candle Filters in the FAT supplied by CECO Filters were of the Graded Bed design with a combination of the roving and mat layers thereby ensuring an ideal combination between pressure drop and acid/gas Separation Efficiency. In this particular case, the GRADED BED™ filter elements were selected to provide ideal velocity limits for Brownian Diffusion collection. No acid carry over has been reported and the pressure loss is also reported to be as predicted.

Customer C

A smelter needed to expand their ore roasting capacity, and had excessive pressure drop through the existing Intermediate Absorption Tower candles with the increased flow. The pressure drop through the existing candles at the increased flow was over 380 mm WC (15 inches WC). The facility considered using an external candle filter vessel to allow for the addition of more candles, however the cost was prohibitive.

CECO Filters was able to offer TWIN-PAK® filter elements to increase the candle surface area in the existing vessel. These filters were installed during a turn-around. Once the plant was restarted and running again, the pressure drop was found to have been reduced to 200 mm WC (8 inches WC). The TWIN-PAK® elements had provided a 47% reduction in pressure drop.

The reduced pressure drop and performance of the filter, along with other modifications to the process, contributed to the debottlenecking efforts. The result of the project was that the Sulfuric Acid plant was able to process more SO_2 from the roaster, increasing the Sulfuric Acid production rate from 1100 TPD to 1500 TPD.

Customer D

A Sulfuric Acid plant using high velocity impaction candles experimented with a number of filter manufacturers and candle designs. This facility experienced chronic spitting problems with which manifested themselves in poor stick test results. In order to control the emissions from the tower, plant capacity was reduced. A number of discussions were held along with analyses to determine why the candles were not performing correctly.

Upon investigation, it was determined that problem turned was with the downstream mesh pad vessel. This mesh pad had been installed to reduce re-entrainment from the impaction candles. In this case, however, the mesh pad vessel was not draining properly. The collected liquid was being re-entrained into the exhaust gas stream, resulting in spitting from the stack. Clearing the mesh pad vessel drain eliminated excessive collection of liquid in the mesh pad vessel along with the spitting.

This is a case where better evaluation of the mist elimination requirements had been made at the time of the tower design, the need for the downstream mesh pad mist eliminator could have been removed. With no additional vessel and mesh pad, there would have been no equipment drains to plug. It is important to consider the simplest and most comprehensive mist elimination solution in order to take away potential for future problems.

Customer E

A cold gas acid plant was producing Sulfuric Acid in a combination of sintered lead and zinc smelting operations. The pressure drop through the Brownian Diffusion filters was very high, and the acid carry-over from the absorption towers was excessive. When a project was undertaken to add a new Sulfuric Acid train at the same site, the customer's engineering contractor contacted CECO to develop a solution. CECO Filters reviewed the problems of the earlier installation and provided system improvement which incorporated CECO's GRADED BED™ design.

On site test results for inlet and outlet loads from the IAT and FAT are provided below. These readings were taken after the plant had been operating at steady state conditions for several months:

Intermediate Absorption Tower Candle Performance

Day	Shift	IAT Inlet	IAT Outlet
1	A	1013 mg/Nm^3	2.2 mg/Nm^3
1	B	866 mg/Nm^3	3.1 mg/Nm^3
1	C	580 mg/Nm^3	12.4 mg/Nm^3
2	A	664 mg/Nm^3	4.4 mg/Nm^3
2	B	800 mg/Nm^3	7.0 mg/Nm^3
2	C	665 mg/Nm^3	6.7 mg/Nm^3

Final Absorption Tower Candle Performance

Day	Shift	IAT Inlet	IAT Outlet
1	A	10.9 mg/Nm^3	4.6 mg/Nm^3
1	B	13.4 mg/Nm^3	2.8 mg/Nm^3
1	C	18.9 mg/Nm^3	2.8 mg/Nm^3
2	A	10.9 mg/Nm^3	3.2 mg/Nm^3
2	B	27.2 mg/Nm^3	5.1 mg/Nm^3
2	C	16.3 mg/Nm^3	6.3 mg/Nm^3

In addition to the excellent mist removal performance, the pressure drop through both the Intermediate and Final Absorption Tower GRADED BED™ candles was reduced by ten percent over the previous all-rope-wound candle filters.

Customer F

A spent acid plant wanted to convert their process from single contact to double contact in order to increase capacity and improve environmental performance. The engineering contractor engaged CECO Filters to provide new filters for the existing Final Absorption Tower and the new Intermediate Absorption Tower. CECO Filters reviewed the specifications for the candles, as well as the specific performance parameters of the plant and recommended a graded bed design to offer the optimum combination of pressure drop and mist removal efficiency.

The Graded Bed candles were installed as part of the plant revamp. After startup the plant was able to meet more stringent environmental requirements easily.

The preceding examples demonstrate that when evaluating mist eliminator filter design in order to increase capacity through a sulfuric acid absorption tower, it is important to optimize the principles of filter efficiency, filter velocity, collected acid drainage and pressure drop. By employing innovative design concepts and maintenance techniques, in order to enhance candle filters performance, the end result can often lead to significantly de-bottlenecking the production process. The result is a more successful project, improved Sulfuric Acid manufacturing capacity and improved system performance and thus, satisfaction for plant operators.

NOTES

Excellence in Pollution Control Technology, Service and Support the World Over.

CECO Filters is a member of the CECO Environmental family of companies.

CECO Filters India Pvt. Ltd.
E-4, CMDA's Industrial Estate,
Maraimalainagar - 603209
District Kanchipuram
Tamilnadu, India.
Phone: 91 44 43168113 and 91 44 43168115
Fax: 91 44 4316 8115
E-Mail: admin@cecofiltersindia.com

CECO Filters
1029 Conshohocken Rd.
Conshohocken PA 19428
Phone: (610) 825-8585
Toll-Free: (800) 220-8021
Fax: (610) 825-3108
E-Mail: sales@cecofilters.com
www.cecofilters.com

CECO

CECO Environmental