Enviro-Chem Systems

A Monsanto Company

Engineered Alloy Products

News Notes

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Sulfuric Acid Tower Technology by Enviro-Chem Systems

As you prepare to replace your sulfuric acid towers, several issues must be addressed before you make the choice of replacement technology that will most fit your needs. Although the concept and practice of using packed towers has been around for decades, significant improvements have been made in recent years that should be considered.

Monsanto Enviro-Chem has been designing and constructing sulfuric acid plants for several decades. This report will examine these issues, the available options and the reasons for choosing MEC technology and experience in executing such projects.

Packed towers are a critical component in the overall operation of sulfuric acid plants. Conventional towers have historically been constructed using carbon steel shells with an inner lining of acid resistant brick. Over the past decade, alloy towers have been used extensively as well. Monsanto Enviro-Chem offers tower designs incorporating both these materials of construction.

Primary criteria in designing acid towers are as follows:

- Analysis and clear understanding of clients' requirements
- Safety
- Optimum performance: low pressure drop, high absorption efficiency and low mist generation
- Cost effective designs
- Ease of maintenance

Designing Towers at Enviro-Chem

Understanding the Process

This is the first and most critical step in the design of acid towers. Replacing a tower in kind is a simple process if no process enhancements are desired. This is seldom the case. Most towers are replaced several years after being installed in initial service. Often, acid plant operators will use this opportunity to also increase capacity. In order to accomplish this, a complete analysis of the plant must be performed to ensure that other equipment can indeed handle the increased capacity. It is important that the client be informed of the specifics of what will be required to achieve the capacity increase so decisions can be made with a clear understanding of the cost/benefit analysis. Enviro-Chem is in the unique position of having designed or built hundreds of sulfuric acid plants - we understand the process.

Designing the Tower

Once the decision has been made to replace or install a new a tower, the design features of the tower becomes the distinguishing characteristics that separate our technology from other alternatives available. The Enviro-Chem tower design process looks at the following set of factors in determining the final configuration of each tower (see fig.1):

- Gas distribution
- Absorption or drying efficiency
- Acid distribution
- Mist generation and control
- Pressure drop
- Structural integrity of the tower and packing support
- Cost/benefit analysis

There are numerous claims made regarding current technology available in the industry and their corresponding effect on the criteria listed above. We welcome this opportunity to clarify and elaborate on these issues.

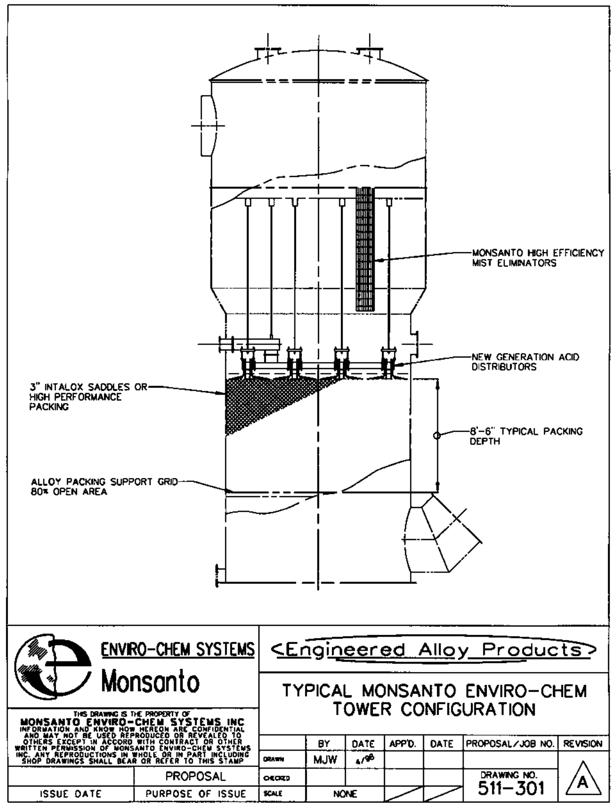

Fig. 1: Typical Alloy Tower from Enviro-Chem. General arrangement.

Tower Packing

Ceramic saddles have been the choice of the industry for many years with good performance results. Efforts have been under way to enhance the overall performance of ceramic packing with some success. Several suppliers now offer ceramic packing with improved performance characteristics. Most notably, pressure drop savings across the packing bed have been improved by up to 50% over traditional packing designs. This improvement does however come at a cost. The improved packing can cost up to 200% of the price of traditional ceramic packing.

Upon detailed analysis, it is obvious where this additional efficiency is most cost effective; an immediate need for capacity increase in an existing tower. As an example, one can expect a nominal 5% increase in flow through a tower for a given pressure drop by replacing the packing in a tower in a 2000 MTPD plant.

Structured packing offers yet more effective gas and liquid distribution with more surface area per unit volume. This type of packing has yet to prove itself as a cost effective replacement for traditional packing. It can be considered for the first layers of packing just above the packing support (if the support system does not afford adequate open area for good distribution).

Packing support

The packing support in any tower is very critical to the overall performance of the tower. Open area should be greater than 65%. Traditional design calls for brick arches, aludur beams and cross partition rings or grid blocks. Self supporting ceramic domes (see Fig. 2) have been used in a very few towers in the US with structured packing still recommended above this dome support.[1] Although this approach does afford greater open area than the traditional arch design, it does not meet cost/benefit criteria in many cases. Drawbacks of this approach include; (a) the time required to install such a support (typically one week or more) and (b) extremely tight tolerances on each block. [2]

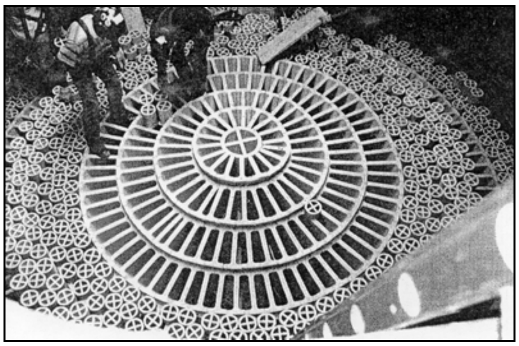

Fig. 2: Ceramic dome support. Note the complexity of assembly and relatively low open area for gas flow.

A more effective approach is the alloy grid support that provides greater than 80% open area with no need for a layer of structured packing, aludur beams or partition rings. The alloy grid can be entirely prefabricated in the shop and shipped in pieces to the site. Installation into a tower can be completed in a few hours. The alloy grid can be installed in a brick or alloy tower, resting on either the brick ledge or alloy chairs welded on the shell. The grid provides the most open area of all designs and ensures optimum gas distribution through the packing. Several brick towers have been retrofitted with the alloy grid support to provide greater tower performance. To date over 30 towers have been built by Enviro-Chem incorporating the alloy grid in the tower design.(See fig. 3 & 4,).

Fig. 3 (top) Alloy grid system. Looking up from the tower base.

Fig. 4 (bottom): Alloy grid system Looking down from the distributor level manway.

Gas Distribution

Most towers are designed based on flooding at the support interface at the bottom of the tower. Monsanto Enviro-Chem towers provide the lowest capital cost design by optimizing the size of the tower. Although flooding is a potential concern for most towers, the “High Efficiency” design has shown no susceptibility to flooding in operation, even though these towers are operating with gas velocities in excess of most conventional tower designs (typical “high efficiency” tower operates at 400 ALFM vs. 200-300 ALFM for most other designs; ALFM is the superficial velocity at the *top of the tower* conditions.).

Much has been made of the need to utilize staggered packing in the tower to enhance the performance of the tower.[3] This approach promotes the use of an outer packing ring of smaller size (see Fig. 5). Unfortunately, this approach does not really address the more fundamental issue - a design flaw with the overall tower design and an inherent deficiency in the acid distributor to irrigate the perimeter of the tower. Reasons for using the staggered packing layout lies in the user's belief that it is gas distribution that's the primary culprit causing poor tower performance. If this were the case, a better approach would be to compare the gas inlet velocity head with the pressure drop and select an appropriate inlet duct nozzle/duct size to minimize gas maldistribution. With proper inlet sizing, the need to always pack the tower "just right" is eliminated. Dual gas inlets have also been considered and even used in some cases. These are usually only used for very large plants and even there, the need is not certain. If these simple guidelines are followed, and *correct and uniform acid distribution is achieved*, the tower will operate effectively for years. The staggered packing layout will improve the performance of the tower at the expense of added pressure drop and increased handling complexity for the tower operators and maintenance personnel.

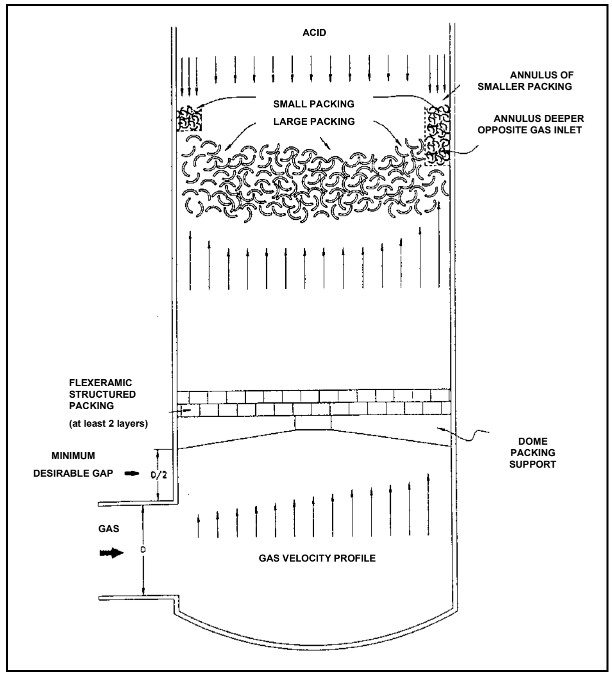

Fig. 5: Staggered packing in a tower.

Acid distributors

The real culprit is the acid distribution system used in the tower. For years cast iron systems have been the norm. A simple test to confirm this is to compare the performance of a tower with a traditional cast iron distributor and a Monsanto Enviro-Chem alloy trough distributor. This test was performed by placing a series of thermocouples in a tower and plotting the bulk gas temperature profile across the cross section of the tower. This was done for both a cast iron system and an Enviro-Chem alloy trough distributor. Results of this test are shown below (see fig.6).

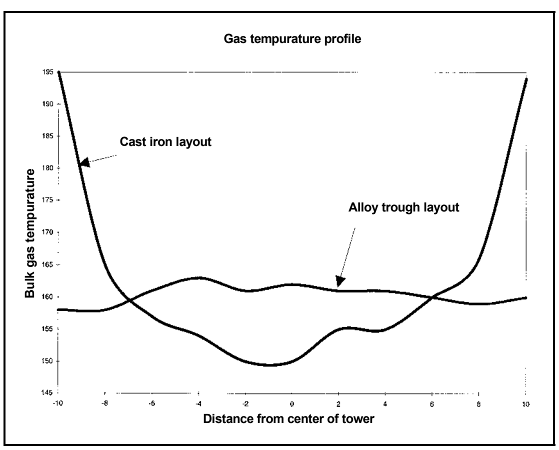

Fig. 6: Gas temperature profile in a tower.

As you can see, for a given gas flow, the overall performance is directly a result of the efficiency of acid distribution. The cast iron system shows extreme maldistribution indicated by the sharp rise in temperature at the tower shell. If gas maldistribution was the primary cause for this, the alloy trough system should not have corrected the problem.

Good acid distribution in any tower is extremely critical to ensure optimum tower performance and maximum service life of downstream equipment. The choice of acid distribution systems must be made very carefully. Current technology available for acid distribution includes cast iron troughs, pipe type and alloy trough distributors. More recently, a hybrid acid distributor was introduced to the market. This distributor attempts to combine some of the features of the pipe and trough distributors. Although this is a marginal improvement over *cast iron pipe and trough systems*, the hybrid does not provide a complete solution to acid distribution. **This approach was used by Enviro-Chem Systems in the early eighties and rejected as a viable solution to acid distribution problems**. The hybrid system like the cast iron pipe system is very prone to pluggage. There is no way to visually examine the system to determine if it is operating effectively since it is a closed system. In the event of a problem, the pipe or hybrid system will have to be completely dismantled even if it is not the source of the problem.

Figure 7 below, shows a hybrid system after several months of service. Note the following shortcomings of this design:

- The teflon tubes that deliver acid to the packing are grossly deformed. The resulting pattern of distribution is not consistent. This system cannot provide uniform coverage across the tower.
- The advantage of this system often touted is the ability to visually inspect and see acid in the tubes. This indicates free flow in each tube. As you can see, after some time in operation, many of the tubes turn to a dark color making such visual inspections impossible.
- The system is very bulky and occupies much of the space in the tower that should be left open for personnel.
- The main header is still highly susceptible to acid corrosion.

Fig. 7: A hybrid distribution system.

Alloy trough distributor technology from Enviro-Chem on the other hand has been proven in over 200 installations to date. The track record of alloy distributors is extremely solid. Figure 8 below shows an alloy distributor in operation after several years of service.

The Monsanto Enviro-Chem alloy trough distributor was first offered on the market in 1987 after extensive lab and pilot plant tests. This distributor was designed with the following key criteria.

- Continuous and uniform distribution
- Resistant to plugging
- Must limit mist generation
- Low pressure drop
- Long life with minimum maintenance
- Must be fabricated from corrosion resistant materials
- Ease of installation
- Ease of inspection
- Must be cost effective
- Easy to clean

Fig. 8: Alloy trough distributor from Enviro-Chem

The unique advantage of the trough design is that it allows for significantly less packing depth which in turn provides a lower pressure drop across the packing. By increasing the number of distribution points (up to 4 pts/ft2), we can reduce the packing height to as little as 7-8 feet in most cases. Pressure drop is reduced in proportion. This is possible only because the distributor can provide very thorough acid distribution over the packing. Other designs including the hybrid design cannot achieve this distribution efficiency. It has been claimed by others that the advantage of going from 1 pts/ft^2 to 4 pts/ft^2 is limited to about 6” in packing depth reduction. This is true for the cast iron trough, pipe and hybrid distributors for the simple reason that these systems can not provide high quality, efficient distribution. The MEC alloy trough distributor is the only system that can deliver this reduction in packing depth. MEC has demonstrated both in pilot plant tests and also in actual plant installations that the savings in packing depth and pressure drop are real .

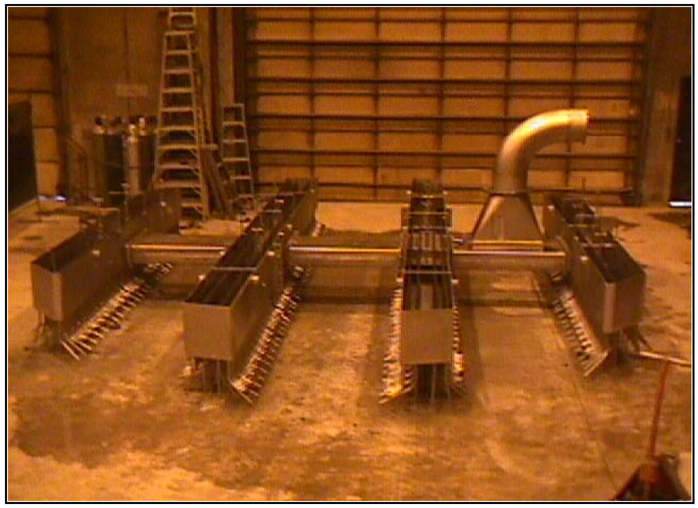

Fig. 9: New generation trough distributors from Enviro-Chem. Assembled for inspection prior to shipment.

Having analyzed all available options, one must then still be able to justify the costs associated with the technology. A qualitative and quantitative comparison is shown for two common examples below to bring some degree of clarity to this equation.

1. In this example, the client is concerned about excessive mist generation in his tower. It has been determined that the cast iron distributor is not performing well and must be replaced. The replacement alternatives considered are:

   a) a cast iron trough distributor
   b) a hybrid distributor and
   c) an alloy trough distributor.

   The tower has a 20’-0” IDB dimension and 14’ of 3” intalox saddles. No capacity changes are desired. The various costs for the different distributor types are shown below.

Cast iron system -	$103,000
Hybrid system -	$110,000
Alloy trough system-	$115,000

2. This example deals with the purchase of a new tower and the cost impact of the various technologies discussed in this paper. The premise is an absorbing tower for a 2000 STPD plant. The current tower diameter is 20’-0” IDB with 14’ of 3” intalox saddles. Pressure drop across the tower is fixed by the client. Assuming a brick lined tower is being considered, the basic costs to provide a replacement tower are shown below.

Item	Enviro- Chem estimated costs		Alternative supplier Estimated costs	
Tower size	18’	$ 640,000	21’-0”	$ 740,000 (larger tower and deeper packing height)
Packing height	8’	$ 34,000	12’ - 14’	$100,000 (Flexeramic™ and HP™ type packing)
Labor to install packing		$5,000		$12,000
Acid distributor	High efficiency design	$150,000	cast iron or hybrid	$110,000 (hybrid distributor)
Packing support	Alloy grid	$120,000	dome support	$110,000
Total price		**$ 950,000**		**$ 1,072,000**

As you can see from this example, the project costs are considerably lower for the Enviro-Chem system. Other issues that one must give great weight to are the technologies being considered and the intangible factors such as experience in the field, track record, reliability, future service and guarantees. The alloy trough distributor and grid support are designed for a service life of well in excess of 20+ years.

Another option is an alloy tower. Alloy towers typically will cost up to 20-30% premium over brick towers but also have a service life well in excess of 20+ years. A true life cycle cost analysis might indeed in some cases, even show the alloy tower to be the economic choice. All other technologies discussed will require complete replacement at least once during the life of the tower.

References

1,3 Cameron G.M, Bhaga D., “Improving sulphuric acid tower performance: A progress report” Sulphur 1996, Vancouver, Canada

2 Zhao Zengtai, Shi Bochao, Gong Baosheng, Dome type packing supports in the sulphuric acid plants. Beijing, China

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