Packing options for sulfuric acid tower repacks

By: JIMMY W. BREAU, P. E.
Process/Project Engineer
Koch Knight LLC, East Canton, Ohio

Fig. 1

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In today's business environment for sulfuric acid producers worldwide, deciding to make any plant equipment expenditure is a difficult proposition. Management expects operations and maintenance personnel to squeeze every drop of economic value from the equipment in place.

When updated or improved mass transfer media are needed, the same management team needs a rigorous economic justification to accompany any expenditure request.

The goal is to repack your towers and provide your plant with a smooth running, profitable operation.

Technical considerations

The necessity for repacking a tower may be clearly indicated to plant personnel by a number of factors, including:

- Excessive pressure drop problems that are producing high energy demand.
- Corrosion caused by moisture present in the gas flow.
- Chips in the acid pump strainers, possibly indicating packing damage has occurred.
- A need for added capacity in an existing tower.
- A general loss of performance in the acid train.

When the technical, operational details of the tower call for a repack, plant personnel need to understand all the packing choices available. Manufacturers of mass transfer media continue to generate improved options for use in sulfuric acid equipment, so there is now an impressive range of options available to the industry.

Packing options

A review of the available packing options for the modern sulfuric acid plant is a good beginning to considering a repack. Fig. 1 shows examples of the three general types of packings on the industrial market today.

Random packing is the industry "workhorse" for mass transfer media. Most towers with random packing are operating with ceramic saddles, although some older towers continue to use various ring types including triple spirals, lessing, raschig and cross partition rings. Some high iron stoneware media still exists, but most ceramic media manufactured today is based on low iron, low leachate ceramic materials.

The widely specified "chemical porcelain" (a ceramic material meeting ASTM C-515 specifications) is a form of such high value ceramic material. Because chemical porcelains generally require a synthetic, blended raw material, they can be more expensive per unit of packing than other choices. Excellent economic performance is available from ceramic products where the iron oxide is tightly held in the ceramic matrix.

A full line supplier should be able to offer both ceramic and chemical porcelain compositions, giving the operator the option to consider the past operating history of the plant with various packings, versus the price differential between the random packing options. There are a range of sizes of random saddle packing. Most sulfuric acid drying and absorption towers get excellent mass transfer efficiency from the USA size 3–inch saddle size. ASTM specifications do not specify the part size, but do give ranges of piece counts for each designation. A general rule of thumb for saddle sizing is that a pair of 3–inch saddles forming a circle is nominally 3-inch diameter on the midline of the rails.

For stripping, SO_2 units, mist eliminator sections and some smaller diameter equipment, 1-inch, 1.5-inch and 2-inch saddles may be required. The packing supplier should be able to advise the operator on the most effective packing size, based on packing hydraulics and process mass transfer requirements.

Fig. 2

Parameter	Base Case	ΔP Reduction	Increased Efficiency and ΔP Reduction	Increased Capacity	Increased Capacity and Efficiency	New Smaller Tower
Packing	3" random	Structured Packing	Structured Packing	Structured Packing	Structured Packing	Structured Packing
Diameter	20'0"	20'0"	20'0"	20'0"	20'0"	17'3"
Packed Height	12'	9'	12'	9'	12'	9'
Gas Flow (lb/hour)	500,000	500,000	500,000	650,000	650,000	500,000
Acid Rate (gpm)	4,700	4,700	4,700	6,100	6,100	4,700
Pressure Drop (" w.c.)	8	3	4	7	8	8
% Flood at Bottom (Max.)	73%	54%	54%	77%	77%	80%

Plant operators and their buyers should provide potential suppliers with process flow rates, and expect in return a recommendation for packing selection including a backup technical analysis. This review will serve to confirm the owner's analysis of the tower's process requirements. If a potential vendor cannot provide such a review, consider whether that vendor should receive further consideration.

Today's production demands can be taxing to existing tower designs. Pressure drop, a minor factor in the "good old days" of low energy costs, can now be a major economic consideration. Standard 3-inch saddles may run pressure drops up to 12 percent higher than the available high-performance options. Such "low pressure drop" random packings are not without their own challenges.

Pressure drop can be reduced by dropping the effective surface area, but this means more liquid flow may be needed to achieve the required SO_3 or H_2O absorption efficiency. Look for a low pressure drop packing design that has limited loss of effective surface area.

The packing must be mechanically rugged, able to withstand standard handling without damage, and must install without the media nesting into itself at a loss of working surface area. An "on paper" low pressure drop that turns into ceramic chips in a pump or a densified bed in practice is a prescription for trouble, not a route to energy savings.

Even a modern, low pressure drop random packing system may not carry the load for today's high demand sulfuric acid towers. Management's view of a recommendation for a new tower purchase will probably not be a positive career move for operations personnel in today's sulfuric acid marketplace. When the maximum performance must be wrung from an existing tower, ceramic structured packing is the only proven option.

Structured packing media apply an engineered design approach in the packing design and its installation. Ceramic structured packing gives acid plant operators the maximum in mass transfer efficiency with reduced pressure drop for the same performance compared to random packings.

Technical analysis of packing options

Fig. 2 shows a recently performed analysis of a set of tower parameters, comparing standard 3-inch saddles to structured packing. As shown, this operator has a number of options available with the application of ceramic structured packing:

- They can achieve a reduced pressure drop from repacking the existing tower.
- They can increase the existing tower's capacity.
- They can combine capacity and efficiency improvements while maintaining the base case pressure drop.
- If a new tower can be considered, it can be more than 13 percent smaller in diameter than the existing tower, while providing the same performance.

A rigorous financial analysis is needed to support the obvious technical advantages of repacking with a high performance packing system. The ability to present such an economic analysis in conjunction with a technical recommendation is a route to successfully funding a high performance tower repack.

Financial analysis

There are many economic analysis tools that can be applied to the fiscal questions surrounding a tower repack. The details of applying these tools to a specific set of tower parameters are available from rereading an Engineering Economics textbook.

They can also be discussed with helpful plant financial personnel able to aid in the analysis and who will likely "speak the language," financially speaking, of the upper management audience. These tools include net present value (NPV), internal rate of return (IRR), modified internal rate of return (MIRR), profitability index (PI) and payback period calculation.

There are a number of variables to identify in order to perform the needed financial evaluation of a repack, including the purchase price, the expected packing life in your facility, your cost of capital, and a calculation of the cash flow series over the life of the packing. This involves a number of plant variables, and is another item to discuss with your finance professional.

Given these data from a plant operation, a financial model that provides guidance for the packing replacement decision can be generated. Basically, the NPV must be greater than zero to prove that making the expenditure for the packing is an economically viable decision.

The evaluation of such financial tools (not to mention the difficulty collecting this data for analysis) is a discussion too long for this article. Suffice to say, working together with your packing supplier to collect the needed data and to perform the analysis should be a step forward toward a successful and profitable repack of a plant tower.

Recap

Don't continue to operate with a subpar process tower. With the help of technically competent packing suppliers, a range of packing options can be found that will meet any tower's needs. By applying the tools of financial analysis, the economic justification for a high performance tower repack can be presented. The final result is a more effective plant operation, and ultimately, a better chance for survival in a highly competitive world.

For more information, contact Jimmy Breau by phone at (330) 488–1651, Ext. 238 or by e–mail to breauj@kochind.com. ❑