Dealing with column fouling

An understanding of process basics and fouling mechanisms enables increased run length in problem columns

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Fouling is an extremely costly phenomenon in the process industry. In a great number of industrial processes, it limits run length, production capacity, and quality. This is especially true with distillation columns where performance at the product separation and purification stage is critical.

Prevention

One of the most difficult aspects of fouling is that the contaminants and processes are often unique to that process. So, as a column designer, even if you succeed in solving a fouling problem in a specific column, there are many other different applications where this particular solution will not likely work as effectively. To solve a fouling problem, it is generally imperative to understand the fouling components in the process as well as the mechanism that creates the fouling issue. Various methods of dealing with fouling are discussed below.

Keeping fouling material out of the column

As with many problems, prevention is typically a much more effective control than subsequent treatment. As such, the preferred solution for column fouling is to keep the fouling material out of the process and equipment itself. Many processes actually use some sort of filtration to accomplish this. One good example is with amine contactors and regenerators. Although filtration is a well proven practice, it can be expensive. Monitoring, replacing, or backwashing filters can be time consuming. Also, there can be an issue with how to properly dispose of the filtered material. Sometimes there is simply too much material to filter practically. Sometimes, the components that cause fouling are not solids until they actually form in the column. In low pressure applications where pressure drop is critical, the pressure drop of the filter system may be unacceptable. So, even though filtration is a very positive method for dealing with fouling materials, it can often be an impractical solution.

Process control to avoid fouling

If the fouling mechanism is due to reaction or degradation of the feed products within the column, then prevention is often a matter of controlling process conditions to keep them outside of the problem operating region. This can often be inefficient and costly from a process standpoint. For any given process, there will be optimal operating points that produce the most valuable product for the least amount of energy consumed. If the process strays from these operating conditions to prevent fouling, this can be more costly with respect to product quality, yield, or energy consumption. A common example of this is a refinery vacuum column wash section. In order to avoid cracking of heavy hydrocarbons, the tower is run at the lowest possible vacuum pressure. Vacuum is expensive to create from an energy standpoint. Also, the wash section in the column is wetted with a heavy gas oil to prevent coking in the wash section. Excess wash oil is used to prevent fouling, but all the excess wash oil is then routed to a considerably lower value product, thus adversely affecting column profitability to control fouling.

Another issue can be with reliability of ancillary equipment. A process can be operating well within its non-fouling envelope but then a temporary pump loss can leave a section too hot or dry and immediately form a coked or fouled section in the tower. Typically, once fouling

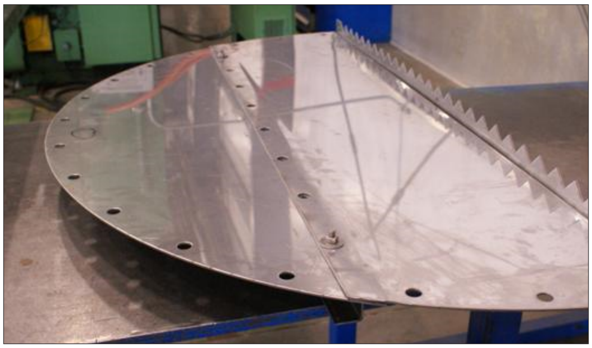

Figure 1 Baffle trays

Figure 2 Tab trays

starts, it tends to grow quickly from that point and create severe problems. Therefore a plant operational excursion can create an irrecoverable fouling situation during a very short time.

Use of anti-foulants
In some select applications, anti-foulants can be used effectively. In processes such as olefin production, the use of anti-foulants is quite common and often effective. The main purpose of anti-foulants is to inhibit polymerisation with the process that will cause fouling. Corrosion inhibitors could also be loosely termed as anti-foulants since corrosion products can form scale and other materials that can foul column internals. Generally, the use of anti-foulants is quite specialised and beyond the scope of this article. Just keep in mind that they do exist and may be a benefit in some services.

Fouling resistant internals
If fouling cannot be kept out of the feed or fouling conditions cannot be avoided by the process operation, then the fouling material must be dealt with within the column. The preferred method is to create internals that simply allow the fouling material to pass through the column without accumulating. In some applications this can be done by using very open, lower efficiency devices such as baffle trays or grid packings. In these designs, the device is so open that there is generally no place for the fouling material to form or accumulate. With baffle trays (see **Figure 1**), liquid cascades down through the column and vapour only passes through the falling liquid vertically between the trays. There are no orifices to plug off and very little capability for solids to form on the decks.

Trays
Tab trays, shown in **Figure 2**, also can be used to keep solids from accumulating on trays. These are conventional trays with liquid downcomers but have directional vapour tabs on the tray deck. The forward directed vapour flow from the tabs can be quite effective in pushing solids from tray deck to tray deck and then eventually out the bottom of the column.

Packing and distributors
When using packings in fouling services, grid packings are typically used because they have large openings and have lower surface areas. The large openings are difficult to plug and thus allow solids to pass through the bed. The low surface area ensures that the entire packing surface is thoroughly wetted and prevents solids from drying out on the surface to cause fouling.

For any packed bed to work well, the liquid distributor operation is critical. This is

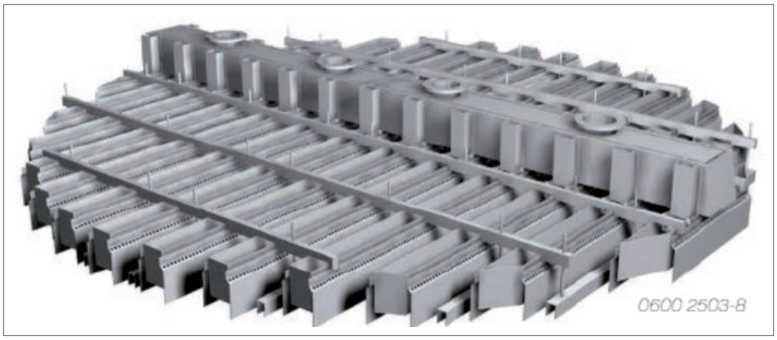

Figure 3 Sulzer VES slurry distributor

especially true for fouling applications. Special liquid distributors for packings can be designed to allow solids to flow through them without accumulating. The Sulzer VES distributor (see **Figure 3**) is used primarily in slurry services. It uses large orifices and minimal dead space to carry solids along with the liquids to the packing below.

Surface treatment

Surface treatments such as coatings or electropolishing can also be used. Dual flow trays have no downcomers and are generally very active on the deck so fouling materials tend to pass through them. The electropolished surface is very smooth and limits the ability of fouling materials to stick on the decks.

Figure 4 Sulzer VEP splash baffle distributor design with raised orifices

Figure 5 Scale fouling on sieve tray

Examples of fouling tolerant designs are distributors that have distribution orifices well elevated off the floor of the distributor to allow solids to settle harmlessly to the bottom of the troughs. A typical Sulzer design (see **Figure 4**) uses side orifices with splash baffles to further distribute the liquid. Specialised parting boxes are also used in fouling designs to allow solids to accumulate without plugging off the flow orifices.

Fouling tolerant internals

The second method of dealing with fouling is to design the equipment to continue working even while fouling accumulates. In this case, the fouling is not eliminated, but the design serves mainly to delay the accumulation of a critical amount of fouling to a reasonable time, knowing that the column will have to be cleaned periodically. Depending upon the fouling and equipment type, sometimes the column internals are cleaned and other times they are simply replaced. Some cleanings will be done with an online wash. Other cleanings will require that the column be opened.

Fouling tolerant packings and internals

Sometimes, designers are reluctant to use packing in a fouling application. Other times, such as in refinery wash sections, packing is almost always used. In these cases, a very large crimp packing is used to allow fouling material to pass through the packing and also delays the onset of crippling fouling conditions by creating large gaps within the bed that take longer to fill. Regardless of what packing type is selected, the liquid distributor must be fouling resistant for any packing to be successful.

Fouling tolerant trays

With tray designs, the orifices are raised from the tray deck and some accumulation of fouling material on or below the tray deck is acceptable, having very little effect on the column performance. **Figure 5** shows a service where scale fouling is accumulating on a standard sieve deck, causing reduced capacity. In cases where fouling occurs on the top side of the deck, raising the orifices off the deck helps substantially. Sulzer SVG V-Grid valves are used for typical fouling services.

For extreme fouling services, the XVG valve, with very large side orifices along with pushing valves have been used successfully in many applications. Some of them are shown in **Table 1**.

Combined tray techniques for fouling resistance

In many fouling applications where trays are needed, several features are combined to increase overall fouling resistance while main-

Potential fouling services for SVG and XVG trays		
Acrylonitrile	**Amine contactors**	**Beer columns**
Butadiene	Caustic wash	Cumene
Depropanisers	Debutanisers	HF alkylation
Latex strippers	PVC slurry strippers	Wastewater towers
Crude stabilisers	Coker main fractionators	FCC main fractionators
Visbreaker main fractionators	CDU/VDU stripping sections	Hydrocracker stripping section
Ethylene oil quench	Sour water strippers	

Table 1

Figure 6 XVG trays in an ethanol plant's beer tower

taining high performance. The Sulzer VG AF tray is such a composite design tray. As discussed previously, high lift, fixed open valves are required for nearly all fouling applications. The combination of large fixed valves with modified outlet weirs (sloped or stepped weirs) and tailored design features make these trays less susceptible to plugging and increase the run time of fouling applications.

Case study: beer column

A beer column in an ethanol plant had plugging issues forcing clean-in-place shutdowns every several weeks regardless of a variety of different tray designs used. Sulzer installed XVG valves in the column in 2014. In **Figure 6**, the column still has some fouling on the decks, but the XVG orifices remained open for a period of over one year.

Conclusions

Fouling in process towers is an ongoing occurrence. Some applications are simply more difficult to process with respect to fouling. However, armed with an understanding of the process basics and fouling mechanisms, engineers can considerably increase the run length of problem columns to an acceptable level by using the proper design techniques and equipment. As a result, shutdowns for cleaning can be minimised and on-spec product time can be maximised. These simple solutions directly increase plant profitability.

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