VALVE TRAY SELECTION

ChewPeng Ang, Sulzer Chemtech, Singapore, reviews the requirements and properties that petrochemical and chemical industries look for when selecting valve trays for their distillation processes.

In order to meet an ever-growing product demand and remain competitive, downstream oil and gas companies are always on the lookout for technologies that can further improve mass transfer capacity, throughput and flexibility. When valve trays are required for gas-liquid distillation processes, their design plays a key role in determining what processing plants can achieve. Therefore, it is important to choose a mass transfer technology with the highest capabilities.

How to decide

Movable valve trays are well-suited for fractionating columns with a wide and fluctuating flow range. When the vapour rate is low, some of the movable valve units will close, thus minimising their tendency to weep. When the vapour loads increase, more valves will open to ensure a more uniform vapour distribution and minimise the risk of entrainment.

Mass transfer component manufacturers can further improve the capabilities of these trays by optimising the design and examining how each detail affects overall process productivity and flexibility. It is important to select a tray technology specialist that carries out extensive research and developmental work together with computational fluid dynamics (CFD) simulations. These give an insight into how the valve design influences fluid flow regimes and dynamics on the tray, during the product development phase. As a result, by conducting these studies, manufacturers can optimise the valve design to deliver high-performance solutions.

A key aspect that needs to be taken into account during the development of valve products is ensuring the valves are able to handle high vapour loads before the onset of entrainment. In addition, the valves should direct the vapour flow closer to the tray floor, to maximise the

interaction of vapour and liquid for mass transfer. This can be achieved by creating a system that reduces the generation of localised high vapour velocities, as well as reducing the froth height, which increases the vapour handling capacity of the tray.

A successful valve design

An example of a proven design is Sulzer's UFM floating valve, which has been successfully installed in over 470 columns for various applications (Figure 1). This features a distinctive dome-like or umbrella shape that reduces the vapour velocity above the valve by approximately 40%, compared to conventional designs. As a result, good mixing on the tray deck and minimal entrainment are ensured. In addition to addressing entrainment, UFM valves can offer capacity increases of 15 – 20% over conventional float valves, while maintaining high efficiencies throughout a wide range of operating conditions (Figure 2).

Maximising column capacity

In addition to carefully considering the optimal design of valves, tray technology manufacturers should also investigate how other components can play a role, including downcomers, which can be optimised for larger column throughput. In particular, in high capacity columns, the bubbling area for vapour-liquid contact should be maximised for optimal mass transfer. While doing so, it is important to ensure sufficient top area and volume for the downcomers for froth disengagement.

An effective approach is combining high capacity decks with carefully designed downcomers, which enhance both the vapour and liquid handling capacity. In addition, it is possible to convert the unperforated deck close to the column support rings into a useful bubbling area. To further boost the capacity, the periphery of these trays can be equipped with directional and movable valves (Figure 3). These tilt at an angle when opened, sending the right amount of vapour flow to the intended direction, boosting the capability of trays to handle higher vapour loads and increasing the overall column capacity.

Based on these principles, Sulzer developed UFMPlus™ high performance trays, equipped with UFM valves and push valves (UFM PV) on the decks, and enhanced downcomers (Figure 4). This solution can be applied on services such as superfractionators, light hydrocarbon fractionators and splitters in chemical and petrochemical applications, where float valves are typically used.

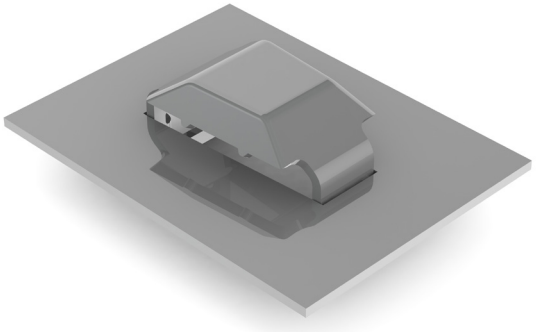

Figure 1. UFM high-capacity floating valve.

Dealing with column fouling

Special considerations should be taken when the feed contains fine particles or the process stream may polymerise to form sediments on the trays over time. This can occur in fouling services, such as stripping sections of crude and vacuum distillation units, coker fractionators, polyvinyl chloride slurry strippers and beer distillation columns. In these situations, offering fouling resistance to extend the equipment service life is extremely important.

In these cases, movable valves are unsuitable, as they tend to get stuck with particles during operation, leading to increased pressure drop, vapour maldistribution and premature flooding. Traditionally, large fixed valves are usually used for these fouling services, however, they may suffer from some losses in capacity and efficiency as compared to smaller valves.

To provide an ideal solution for such operations, it is necessary to develop valves that can meet high hydraulic

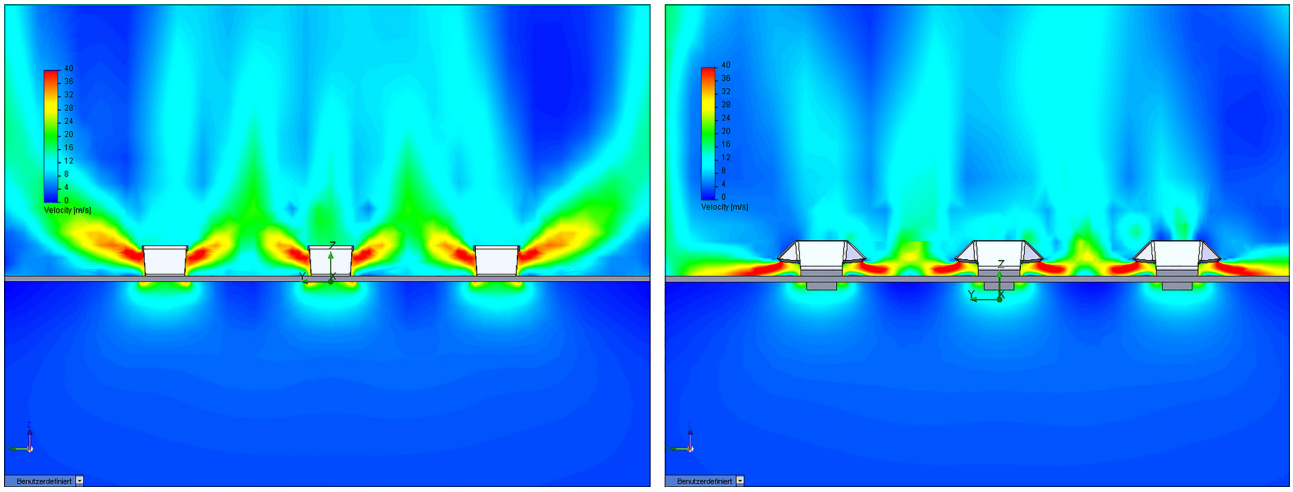

Figure 2. CFD study of vapour flow from conventional valves (left) and CFD study of vapour flow from UFM valves (right).

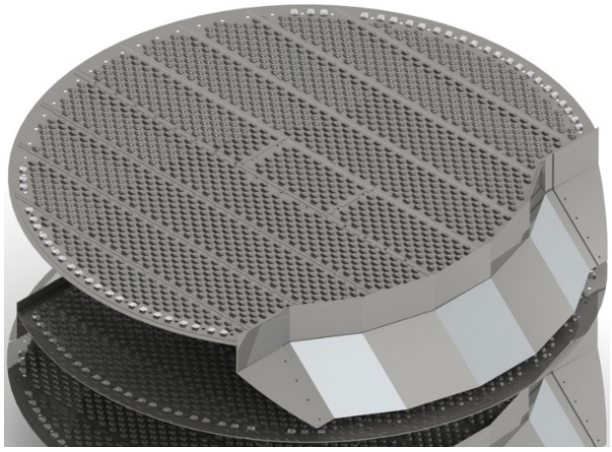

Figure 3. UFM push valve.

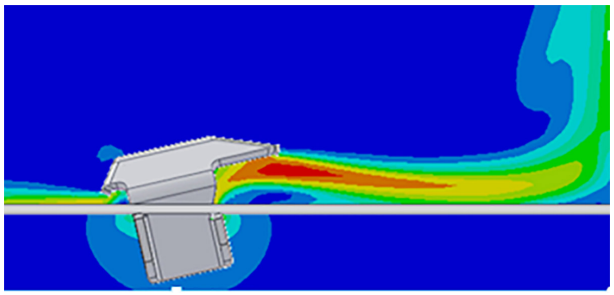

Figure 4. CFD simulation of vapour flow when using UFM PV valves.

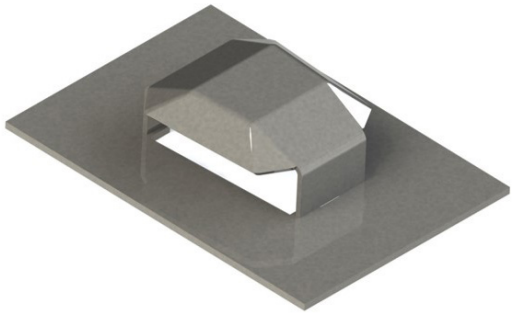

Figure 5. UFM AF anti-fouling valve.

demand while offering optimal fouling resistance that maximises equipment's service life.

Sulzer's UFM AF anti-fouling valves have been specifically designed to address these issues (Figure 5). These large fixed valves, bearing the signature umbrella shape, have at least 10 – 15% higher capacity than conventional fixed valves. UFM AF valves can be combined with other anti-fouling design features such as sloped or stepped outlet weirs and flow directing push valves, to minimise the accumulation of particles on the tray decks.

Addressing any customer requirement

Choosing a mass transfer technology specialist that can address general and specific separation needs and challenges can help plant operators to fully leverage the capabilities of their facilities and strengthen their competitiveness.

With Sulzer, for example, process industries can benefit from a wide portfolio of high-quality trays and associated components that meet every requirement of modern industrial processes. In particular, the UFM family of valve trays ensures state-of-the-art capabilities for a broad range of applications.

Case studies

Meeting stricter environmental regulations

A reformate splitter – which receives naphtha from the upstream catalytic cracking reformer (CCR) and removes benzene and lighter components in the distillate – was built in a refinery in Texas, US, in 2009. This column had 61 trays, which were originally equipped with fixed valves.

A few years later, a new environmental regulation from the US Environmental Protection Agency (EPA) came into force requiring blended gasoline to have less than 0.62% benzene by volume. In order to meet this condition, the reformate splitter would face a 15% increase in feedstock in order to remove more benzene. As the column was already operating at maximum capacity, the existing fixed valve trays could not handle the additional feed rate.

Sulzer supported the refinery by replacing the existing fractionation trays with UFM tray decks and sloped downcomers. After the revamp, the column has been running smoothly, delivering products that meet the required specifications and achieving an optimal process efficiency.

Boosting throughput by 50%

A phenol production plant in China, built in 2004, was planning a 50% increase in phenol production rates, shifting from 200 to 300 tpy. In the Benzene column, separating benzene and isopropyl benzene, the existing sieve trays could not handle the new loads.

Sulzer conducted an extensive hydraulic evaluation and concluded that 25 trays in the bottom section below the feed inlet were bottlenecking the unit. In addition, it was necessary to replace the existing straight downcomers, whose size was inadequate for the new loads.

To address these issues, Sulzer supplied UFMPlus high performance trays, with enhanced downcomers to maximise the bubbling area, as well as UFM PV to further boost the vapour handling capacity. The new trays could minimise pressure drop and the risk of entrainment, improving the overall column performance. As a result, the plant succeeded in boosting its production rates.

Conclusion

When specifying new valve trays, it is beneficial for companies in the process industry to take advantage of expert mass transfer technology providers. The design of trays and valves can influence productivity, efficiency, column capacity and equipment service life. By selecting the right provider, businesses can benefit from high-quality, reliable, durable and flexible components. These solutions should not only suit their intended applications, but also offer maximum performance.