COMBATTING CHALLENGING CONDITIONS

Rebecca O'Donnell, Baker Hughes, USA, offers a field-proven solution for an erosive control valve application.

The crude unit is the first step in the process of refining crude oil downstream. This step provides feedstock to all other areas of the plant for further processing. When raw crude is transported into the unit, it is first treated to remove salt for corrosion prevention. It is then heated up to 750°F and is piped into the bottom portion of the atmospheric distillation tower. The tower operates at an atmospheric pressure of up to 30 psi, and has a series of trays with perforated holes and structured packing throughout.

As the preheated crude is fed into the bottom of the tower, the lighter hydrocarbon molecules vaporise, rising through the tower. Depending on the boiling and condensing points of the process media, it can change to liquid form as it rises in the tower. The lighter hydrocarbons (C1 – C4) rise to the top and are partially condensed into liquid by heat exchangers. Part of this flow stream is brought back into the tower as a liquid to cascade down through the tower at a lower temperature, purposefully encountering the rising vapour. This generates a cross flow that stabilises and creates an equilibrium throughout the column.

There are streams with different boiling and condensing points at select heights in the column. Each stream is unique, and used to make different products. The streams of 'distillation cuts' or 'fractions' are syphoned off and piped from the outside to different areas of the plant, for further processing. Columns are designed and built for specific grades of crude, and the plant's ultimate production is determined by how efficient these columns are. At the bottom of the distillation tower there is a liquified heavy mixture of leftover components from the crude separation process. The boiling point of these components is 650°F or higher. Known as 'bottoms', it is important to keep this mixture of heavy hydrocarbons at a controlled temperature so that they do not solidify or change composition. The process could be severely damaged if this does happen.

The 'bottoms' are taken from the bottom of the distillation tower to flash furnaces in preparation for the vacuum distillation unit (VDU). The transport and control of this fluid to the next step is a challenge. The temperature must be kept at 650 – 750°F in order for it to be maintained as a fluid, and abrasive particles suspended in the mixture, along with other corrosive components left over from the raw crude, must be considered. Additionally, the correct valve solution must be able to handle flashing, erosive particles, corrosion and high temperatures, while maintaining good control, shut-off and function for as long as possible between maintenance cycles.

The vacuum distillation tower further separates the heavy mixture into gas oils. With lower operating pressure, the media can vaporise and separate without raising the temperature, preventing thermal cracking, and avoiding the formation of petroleum coke, which is detrimental to equipment and piping. This is because the process mixture contains components with higher vapour pressures.

The process functions much like the atmospheric distillation column – except under pressure. The inlet fluid is kept at a temperature of no more than 370 – 380°C with a pressure of 10 – 40 mm of mercury (mmHg). This allows some of the heavy mixture to vaporise immediately, producing a viable product that would not be able to be extracted in the atmospheric tower. Operating at this temperature prevents cracking and further unwanted reactions, as a result. Operating at low pressures increases the volume of vapour, and is noticeable by the size of a typical vacuum column. With diameters of up to 46 ft and heights of up to 164 ft, the inside of the tower is mainly filled with packing to increase surface area between liquid and vapour. Trays are only present at levels where the product is extracted from the side of the tower.

The 'bottoms' that go into the vacuum resid bottoms valve are particularly harsh, and from this process go on to the coker or are cut into residual oil. At 630 – 680°F, this process is challenging to control based on the abrasiveness, flashing and temperature of the media. Proper configuration of control valves for this application should be selected to maximise efficiency and withstand a very harsh environment, and these should last five to seven years on a maintenance cycle.

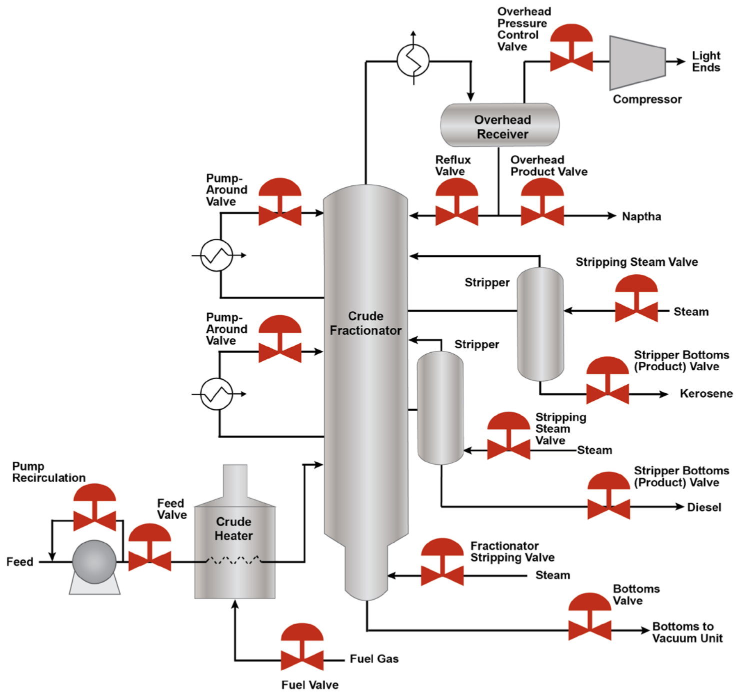

Figure 1. Illustration of the atmospheric distillation process.

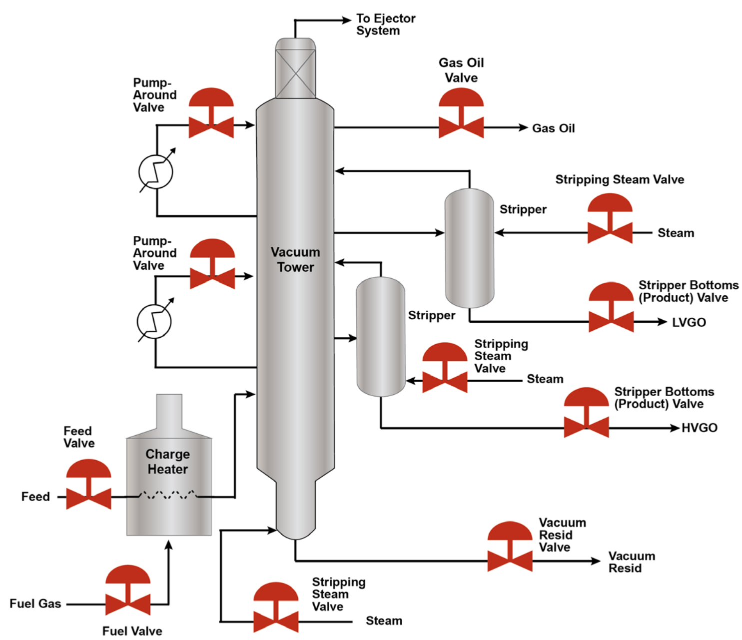

Figure 2. Illustration of the vacuum distillation process.

Specific challenges

Temperature

Temperatures across these processes are high and need to be maintained to produce the best product with optimal output. The high temperature range creates challenges for control valves, but is required in order to keep the crude components flowing so that they do not solidify and clog the valve. This introduces complexity when selecting a control valve, because the supplier needs to consider the best valve geometry to ensure that it has minimal dead spaces for fluid to collect and build up. This leads to stiction (valve stickiness caused by excess friction), causing issues with control and flow, and reducing the life of the valve in turn.

The other points to consider are trim components that are in close tolerance to one another. Thermal expansion can occur, thus causing dissimilar parts to expand at varying rates. This can lead to galling of internal valve parts, excessive wear, and irreversible damage, compromising valve function. Lastly, high temperature affects the packing materials being used. The bonnet length and temperature limits of a valve should be considered. Bonnet length is important as it creates a barrier between the control valve packing and process fluid. If the fluid exceeds the packing temperature rating, then the packing can be compromised and fail, leading to process leaks and fugitive emissions.

Pressure

While the pressures are not significant by control valve standards, the media contains a number of hydrocarbon components with different vapour pressures, which can lead to flashing. Flashing

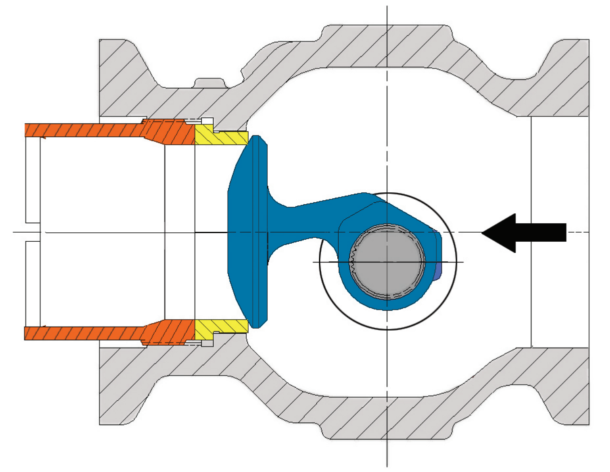

Figure 3. Flashing can be directed further downstream of the valve with an extended retainer to protect the valve body and components, as well as downstream piping.

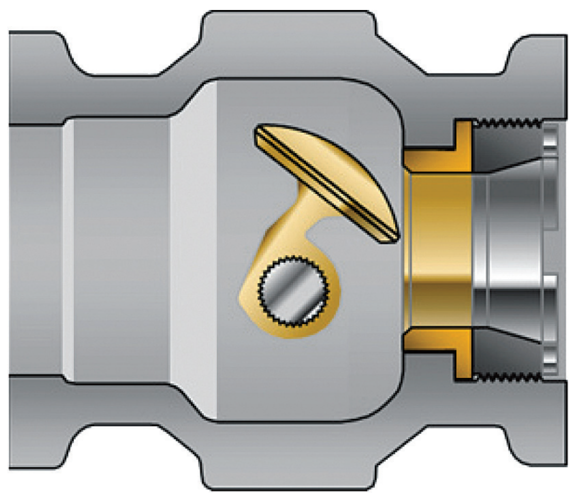

Figure 4. The plug design of the Camflex eliminates all plug and seat contact when the valve is in the open position.

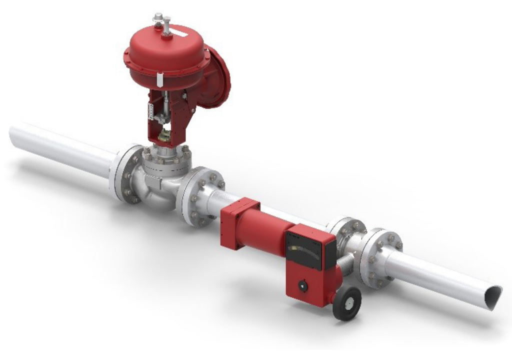

Figure 5. The reduced size and weight of the Camflex compared to traditional globe valves eases pressure on the piping system and allows for more flexibility of process design, with no sacrifice of flow capacity.

occurs when a process fluid in liquid form converts to gaseous form when it drops below its vapour pressure as it passes through the vena contracta and remains in gaseous form. The expansion of gas and the high velocity with which the remaining fluids and particulates are carried in the direction of metal boundaries can erode and damage anything in its path. Depending on the valve style and where the vena contracta occurs, this could mean erosion in the body and/or valve components. Valve geometry and metallurgy must be considered in order to extend valve life. It is always good to check any downstream piping, such as elbows, or other equipment that can be affected.

Emissions

The elimination of fugitive emissions is becoming a standard in many refineries, especially with federal agencies monitoring, and most plants now impose a less than 100 ppm standard. As a result, choosing the right fugitive emission packing for temperature, pressure and plant specifications is a requirement. ISO 15848-1 certifies packing by cycles, leakage, and the temperature that a valve can maintain over time. This is a common certification that is accepted by most customers.

Solutions

For these severe process conditions, a control valve such as the Masoneilan™ Camflex™ is an excellent solution for several reasons.

The simple design allows the plug to move away from the seat when the valve opens, eliminating contact until the valve closes. This means less potential for erosion and wear between the plug and the seat. The valve geometry is straight through, so there are no tortuous paths for points of impingement and wear in the body. Unlike other rotary solutions, the Camflex can be sized with reduced trim to position the plug open and further away from the seat. This helps to prevent throttling too close to the seat. To further mitigate wear in the body, the Camflex can be configured for 'flow to close' so that the fluid passes through the body and the pressure drops outside of the body, allowing for a higher velocity and for flashing to take place at the outlet of the body.

The Camflex has an extended retainer option to direct flashing downstream of the valve without any direct impingement on the valve surfaces. This protects the valve, as well as downstream piping. This extension can be manufactured from various materials based on customer requirements and best erosion resistance properties.

The EF seal design with double O-Ring sealed packing is designed into a single body and bonnet, allowing for a single leak path and better sealing rated to 750°F.

At half the size and half the weight of a traditional globe valve, the Camflex can go where many valves cannot. Its capacity is considerably larger than a globe valve at the same line size. Cost savings can be achieved by using smaller valves to maintain process efficiency with reduced piping stress.

Conclusion

While the conditions are extreme in the crude unit, and there are many associated process challenges, efficiency and productivity can be maintained if proper consideration is taken for optimal valve selection.