SEPARATING THE WHEAT FROM THE CHAFF

Mark W. Abbott, ValvTechnologies, USA, focuses on methods of keeping gasification reactor filters clear, allowing syngas to be efficiently separated from char.

The process of refining crude oil has transformed the lives of countless people and cultures over the last 100 years. As various length hydrocarbon chains are extracted in a distillation tower and bound for a myriad of uses, the remainder of the crude oil ultimately settles into a state called coke. Striving to recover every last ounce of energy from the hydrocarbons, the coke is processed in coking and delayed coking units which provide both solids and gases for downstream industrial applications. The residual solids from the coking process are still highly energy-rich, but difficult to refine into usable product. To squeeze more energy and product from the coking residuals, the gasification process was born.

Gasification reacts the coke residuals in a controlled environment to break down the polymers. After gasification is performed, the outflow from the gasifier contains both char and syngas. While the char has little monetary value, the syngas can be sold commercially for use within the plant or other applications, including power generation and chemical production.

Several different methods exist to separate char (the soot-like byproduct from the combustion in the gasification reactor) from syngas, but a common method is to use a filter to collect the char as the syngas flows through. The char is returned to the char reactor and the syngas can then flow downstream to its destined use. Typical filters are mesh-type to capture any particle beyond a certain size. These filters, however, suffer from the issue of the char building up a cake (a build-up of char on the filter opposing flow) on the upstream side of the filter, reducing the flow. To remove the cake, one method

is to use a pulse of syngas against the flow of the unit, into the filter, to cause the char cake on the underside of the filter to break up and then fall back into the reactor, as shown in Figure 1. This method allows the built-up char to be removed autonomously during unit operation and does not create any additional outflow to be handled.

Solution

ValvTechnologies designed and manufactured a pulsejet valve to control the flow of syngas needed to disrupt the formation of the char cake. The valve satisfies the service conditions for operation of eight months or more, depending on its actual cycle time.

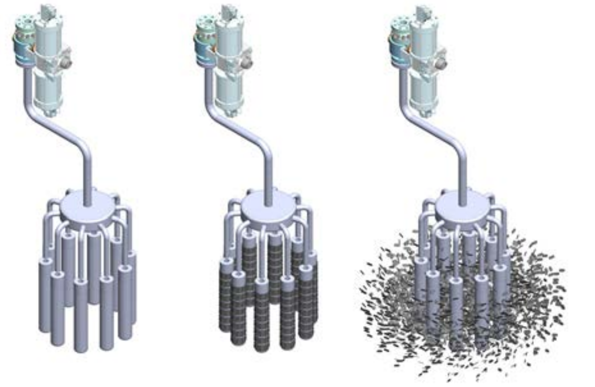

Figure 1. A pulse of syngas breaking up char cake on the filter.

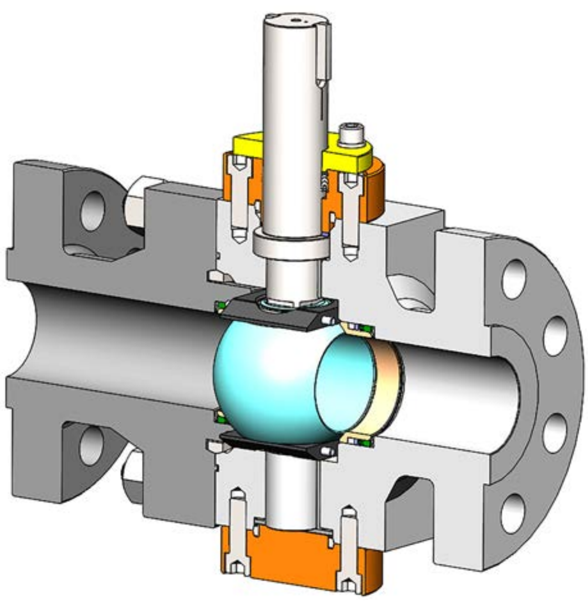

Figure 2. ValvTechnologies' pulsejet valve design.

Table 1. Pulsejet valve requirements	
Nominal valve size	3 in.
Pressure class	1500
Cycle time	~0.75 sec.
Dwell time between cycles	90 sec.
Mean time between repair	8 months
Approximate number of cycles	250 000

Development

The valve was designed to meet harsh end user service requirements. A subset of the total requirements is shown in Table 1.

The requirement on cycle time for a 3 in. line is based on the need to provide a pulse of gas that is both fast enough to bridge the gap to the filter and voluminous enough to impact the filters with enough force to break the cake off the outside of the filter. The parameters of each pulse of syngas have been calibrated by an independent organisation such that the pieces of cake are both large enough to fall back into the reactor, but also small enough to break away easily. The ball valve is the preferred geometry for this application because of the round, straight through port, delivering the best flow profile with the lowest back pressure. In application, the gas flows upward through the filters, allowing gravity to carry the broken cake away from the filter naturally, as shown in Figure 1.

Product

The valve used to create the burst of syngas is based on a trunnion valve design with stems both above and below the ball. Combined with the trunnion blocks, the position of the ball is secured within the body, and the rotation of the stems is held tightly to the centreline with bushings in place to minimise metal-to-metal contact and galling as shown in Figure 2.

Due to the required cycle time, the motion of a traditional quarter-turn ball valve is unable to properly control the flow of gas, because the valve stops in the fully open position as it must change direction to go from opening to closing. To overcome this, the valve uses a special actuator which allows the ball to rotate 180°, not stopping in the fully-open position. In rotating the ball through 180°, the actuator places the downstream side of the ball against the upstream seat and the upstream side of the ball against the downstream seat, requiring a ball lapped completely around to both upstream and downstream seats.

Rotating a 3 in. ball 180° in 0.75 sec. will exceed the pressure velocity (PV) limit for many materials, which results in galling. The PV limit is commonly used in bearings and defines the highest combination of load (pressure) and speed (velocity) under which the material will successfully operate. ValvTechnologies selected a material which combines the toughness to serve as a seat but also a strong enough set of material properties to remain below the PV limit and avoid galling at the speeds and under the loads that the valve experiences when it cycles.

In order to develop and confirm the performance of the valve, a multi-year long development program was undertaken. Initially, the product was being developed for several industrial customers. Once the initial revision had been installed and was shown to perform at a level below expectations, ValvTechnologies partnered with a company engaged in the energy and petrochemical industries to develop the product revision. Laboratory testing was performed and ideas from both organisations were combined to create the product solution.

One of the requirements that the pulsejet must meet is compliance to ISO 15848. Fugitive emissions requirements are quickly becoming one of the most crucial topics in the valve industry. With increasing regulation, safety and environmental concerns, and the need for operational efficiency, it is easy to understand why these requirements exist. Even for a standard valve, achieving a fugitive emissions' certificate per ISO 15848 is not a simple task. In the case of the pulsejet valve, which cycles much faster and more frequently than a standard valve, the task is even more daunting.

During testing, as shown in Figure 3, it was identified that the seals initially selected would not meet the ISO 15848 requirements. As new seals were needed, the proprietary EcoPack® stem sealing solution was developed. The seal met ISO 15848-1 type testing requirements and was additionally tested in the strenuous conditions of actual operation.

A major milestone in the development of the revision of the product was the addition of the lower stem. This moved the valve from a pseudo trunnion into

Figure 3. Pulsejet valve testing in high-pressure bunker.

a true trunnion design, providing additional support for the ball during rigorous cycling. The product also benefited from the addition of dowel pins added between the trunnion blocks and the body and end cap to reduce the relative motion between these parts to nearly zero. The pinned components now hold the ball in a fixed cage, with the trunnion blocks above and below and the body and end cap on their respective sides. The stems can pass through the trunnion blocks to rotate the ball as shown in Figure 2. The seat was improved to have a larger contact area with the ball and a longer body, which helped to stabilise the seat in the seat pocket. Bushings were added on both the upper and lower stems and a lower bonnet was added as well, allowing the lower stem to be installed from the underside of the valve.

Application

In application, the pulsejet valve cycles approximately every 90 sec. Over an eight-month target life, this is roughly 250 000 cycles. The laboratory was configured to test two pulsejet valves simultaneously, at 450°F and under a closed valve differential pressure of 1160 psi. In total, 10 valve seat materials were tested, with millions of cycles across several rebuilds of each valve. Laboratory tests were performed at a faster cycle rate than in application, to help expedite the results to find the solution. Typical laboratory cycle time varied over time, but averaged around 6 – 9 sec. per cycle. The leakage across each seat was tested daily and tracked with leakage beyond 100 l/min. at 1160 psi deemed unacceptable for a sustained period of time. Early tests only completed 25 000 or 30 000 cycles, where later materials were achieving closer to 100 000 cycles. The final winner was able to achieve over 210 000 cycles. The success of the material was immediately identified, and the design was put into production to get it to the customer as quickly as possible.

The first-generation equipment installed on site was pulled from the facility, as the facility was still in the process of being commissioned, modified and rebuilt at locations nearby. The updated valves were inspected, approved and then placed back in line at the refinery. To date, the valves have clocked over 50 000 cycles without notable issue and continue their path to an equivalent eight-month performance.

The customer represents the largest petrochemical refinery in the world, capable of processing nearly 1.4 million bpd of oil. This processing takes an immense amount of energy. The customer saw the opportunity to increase profit margins by using their own petcoke feedstock waste to produce syngas, which is recycled back into power generation for use around the plant. The syngas production will eventually remove the need for the customer to import LNG and allows them to use the nearly 6.5 million t of petcoke residual from their own coker units. This process is made possible in part by the efficient and reliable cycling of ValvTechnologies' pulsejet valve.