HYDROCARBON ENGINEERING

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Collaborating for flow *solutions*

MOGAS Industries discusses designing valve solutions to meet a changing market.

During the Fit for Purpose workshop at Valve World Americas 2013, an international attendee addressed the panel of experts expressing his frustration with valve companies that are only interested in selling what is on their shelf. As a consultant in a refinery, he was dedicated to keeping the plant running, and his experience was that failed valves were being replaced by the same type valves, knowing that they were going to fail again; there was no interest from the manufacturer of the failed valve to find a solution for his customer's particular application. Can this be true when so many valve companies claim to sell 'solutions'?

While there are no statistics or surveys to validate the attendee's claim, shifts in the refining market and technology are placing greater demands on valve manufacturers to do more than just sell valves. It is now becoming necessary for manufacturers to partner with customers to provide solutions to unique processes or problems.

This is especially evident when processing unconventional oil. Unconventional oil generally consists of a wider variety of liquid sources including oilsands, extra heavy oil, gas to liquids and other liquids. As the easy oil runs out, conversion type units are on the rise.

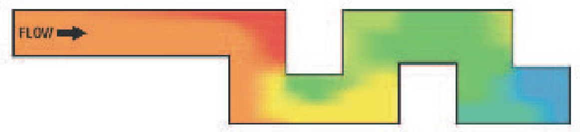

Figure 1. This CFD simulation in a control valve shows that by forcing process fluid to turn through a predetermined series of angles, kinetic energy is dissipated and velocity controlled.

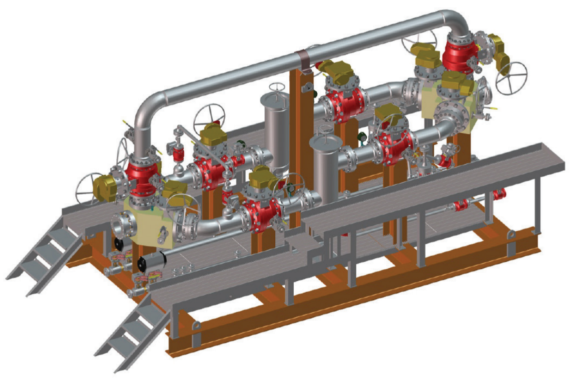

Figure 2. The modularisation of this entire letdown station solved multiple problems, and is evidence that changing people's perceptions and work habits are the biggest challenge when offering creative solutions.

Everyone wants to buy the cheaper crude, such as heavy, sour, high acid oilsands crude, and convert it into sellable products. Complications from this type of crude push refinery infrastructures to their limits as plants are always looking to make units more profitable, more reliable, safer and in compliance with environmental requirements.

The complications of heavy oil

When processing residual heavy oils, mechanical equipment is punished by high pressure, high temperatures and corrosive/erosive media, such as salt, particulates, metals, sulfur and naphthenic acids. The heavier the feedstock, the higher temperatures and pressure needed to break apart hydrocarbon molecules, and the more difficult it is to enclose and hold pressure from leaking out. In main process lines where temperatures range from 450 - 1500 °F, fluid streams become heavier, more viscous and tougher to handle. Waxes start to build up and asphaltenes solidify. Also, when temperatures increase, coke is formed and builds up in pipe elbows and mechanical equipment, such as pumps and valves, plugging flow paths and eroding metal surfaces.

Fit for purpose

Severe service valves that are not designed for specific applications are prone to fail. In applications involving high temperature and heavy coking, rotary valve designs that are compact with few moving parts and minimum small cavities are ideal. Tortuous path valve designs, such as gate and globe that require the stem to move in and out of the packing box, invite debris buildup and fugitive emission issues, require more frequent maintenance and often do not perform well in these services.

Special valve trim and purging configurations need to be considered to combat coking and valve seizure in heavy oils units, and specific coatings and thermal sleeves may be required in applications where high sulfur feedstock tends to leach out nickel from the binders.

Metallurgical selection plays a significant role in valve design, performance and, ultimately, plant and employee safety. This is especially critical as crude moves to a more corrosive state, with napthenic acid attacking the grain structure of carbon steels or chrome molys. Stainless steels, such as SS316 and SS304, are common materials and contain chromium to resist corrosive attacks. Specially designed austenitic stainless steel, such as SS347 and SS321, are required at higher temperatures (500 – 800 °F).

Developing flow solutions

Valve design is really about flow control, not about the valve. To understand what type of valve works best in a particular application, which materials are chosen and what features are incorporated, one has to understand the complications of what flows through the valve.

- How fast and how often is shut off required?
- What is the temperature and pressure range, and how fast do they change?
- What are the contaminants that will contribute to corrosion and erosion?
- How will the temperature/pressure/catalyst change the media?

Only when a valve manufacturer partners with a plant engineer or a process engineer to understand their whole flow process, and what they are trying to achieve, can a solution be proposed.

Tools used by valve design engineers include computational fluid dynamics (CFD) software to solve and analyse problems that involve fluid flows (Figure 1). CFD analysis can predict the complex flow characteristics inside the pipeline and valve, where issues such as the formation of vortices and complex cavitation phenomena can be visualised. When used with finite element analysis, to simulate material stresses, and flow loop validation, CFD gives engineers a complete picture of where to improve valve performance.

Part of the valve solution cycle is also examining why valves fail. During a 'take down', engineers autopsy and analyse failed valves to discover their weakest links. By finding out what works and what does not, improvements to design and material can be made. Customers want valves to work better. They want their process to work longer and faster with an increased capacity. A valve may have done its job by working two years as planned, but customers want it to last four years.

Case study: Modular process units

The engineering and construction of an upgrader/refinery to convert bitumen to high value, ultra low sulfur diesel was a challenging project for the EPC since this heavy residue hydrocracker unit was to be only the ninth in the world of its type and sophistication constructed since 1982. Obstacles caused by the shortage of a skilled labour pool in the area, a lack of technological expertise and a 2016 start up date presented difficulties, which required creative solutions.

The solution was for a single source to supply modular process units (skids) for all redundant control valve letdown and filter stations within the unit (Figure 2). The benefits of this modularisation strategy applied to key components that could be incorporated into the currently offered designs. The flexibility afforded by this approach allowed for improvements that would reduce downtime and improve overall plant safety. The benefits of automating and combining sophisticated controls for the switching process, which included flushing, purging and pre switching warm up cycles, went directly to the bottom line of the project. Operator errors that could cause equipment failures, resulting in unplanned shutdowns, were eliminated. A modular approach would also reduce costs by providing a:

- Smaller plant footprint (reduced to 40%).
- Significant reduction in man hours for design and onsite labour and construction.
- Reduction in logistics required for multiple vendors, purchase orders and deliveries.
- Minimal site risk management through parallel work to be undertaken.
- More efficient work process through centralised activities by third party inspectors.

Further savings were also realised by modularising other operating units of this project, including the fixed bed hydrocracker, distillation units and the gasification unit.

Case study: Erosion sleeves

When an EPC recommended rotating disc type valves in a resid fluid catalytic cracking automatic catalyst withdrawal unit for a large Southeast Asian refinery, the plant project chief wanted a longer lasting solution. Previous valves had premature failures caused by high temperatures in excess of 1290 °F and 50 micron catalysts. The valve's expected run time was a minimum of 12 months.

After R&D engineering, the solution included a ball valve design with an F347 body and an Inconel 800H ball and seat. A cobalt nickel alloy coating was applied to the ball and seat, and along the entire flow path of the valve. This proprietary coating provided good metal to metal wear protection because of its erosion resistance and low coefficient of friction properties. As a mechanical redundancy, a replaceable sleeve was designed to protect the entire valve body and end connects from severe erosion, saving on the capital equipment. Additionally, body and seat steam purges would help to keep the valve clean, lengthening the valve's operational life.

Preventative solutions

As the above two case studies show, creative engineered solutions can be developed when valve manufacturers and end users work together to solve process problems. But what happens after the solution is in place? Process efficiencies and reliability are driven by the performance of critical equipment, and sustaining optimal valve performance is achieved through proactive, predictive and preventative maintenance. The more you know about the equipment that is critical to your operation, the more one can avoid unplanned downtime situations.

In plants where key unit personnel have years of site experience, problems can be anticipated and solutions planned in advance because of their accrued knowledge. But, as more experienced personnel are 'ageing out', the depth of knowledge is not being transferred to their younger replacements. This brain drain is compounded by the frequent rotation of unit personnel who have to come up to speed with the unit's history of equipment and maintenance schedules, all without being able to lean on the experienced guy who has been moved on to another unit.

This change in workforce practice makes it necessary for plant managers to look to valve manufacturers to provide solutions, such as valve management programs and asset management. This type of partnership gives unprecedented insight and control of client specific interactive databases that offer real time visibility, access and analysis. Additionally, unit walkdowns performed by experienced valve technicians, who use contemporary technology, capture valve performance data. All this data is not only valuable to valve engineers, who can analyse the dynamics and kinematics of each valve, but also transfers the unit's valve history to new plant personnel.

As refiners continually evaluate unit modifications to increase capacity, improve product yields, and maximise onstream factors and mechanical reliability to be more profitable, valve manufacturers are tasked to improve their products and services to meet these demands. Improvements to valve designs, coatings, materials, engineering and service are a significant part of the solution, which can only be realised when manufacturers and end users partner to conquer the unique problems of processing the heavy oil of the future. HE