

Triple Offset Valves for Molecular Sieve Applications in Ethylene Production

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Switching valves used in molecular sieve applications (cracked gas drying) in the ethylene production industry face several operating challenges that may link to increased plant downtime, product loss and environmental pollution. Key end users and licensors have long been seeking alternative solutions to the standard valve product design for this application. Over the years, Emerson Vanessa has acquired the know-how necessary to manufacture an exceptionally reliable triple offset valve that meets and exceeds the level of performance required with minimum maintenance and long life expectancy.

KEYWORDS

Ethylene, Valves, Petrochemicals

Las válvulas de conmutación utilizadas en aplicaciones de tamices moleculares (deshidratación de gas craqueado), en la producción de etileno, se enfrentan a varios desafíos operativos que pueden vincularse con el mayor tiempo de inactividad de la planta, la pérdida de productos y la contaminación ambiental. Se han buscado soluciones alternativas al diseño de productos de válvulas estándar para esta aplicación. A lo largo de los años, Emerson Vanessa ha adquirido el know-how para fabricar una válvula triple offset muy fiable que cumple y supera el nivel de rendimiento requerido con un mantenimiento mínimo y una larga vida útil.

PALABRAS CLAVE

Etileno, Válvulas, Petroquímica

IN LIGHT OF AN INCREASED COMPETITION on a global scale and subsequent pressure on increasing plant efficiency, reducing capital and operational expenditures without compromising safety, reliability, and performance is paramount. This article explores the adoption of Vanessa Triple Offset Valves (TOVs, Figure 1) as a cost-effective solution in cracked gas dehydration by adsorption on molecular sieves vis-à-vis the existing standard valve technology, namely the design principle of a rising stem ball valve.

ADOPTING TRIPLE OFFSET VALVES ON MOLECULAR SIEVES FOR CRACKED GAS DEHYDRATION

In an ethylene plant, the cracked gas is saturated with water before compression and after each intercooler stage, therefore it needs to be dried before fractionation to prevent the presence of ice at low temperatures. This is typically done by chilling and by adsorption using molecular sieves. The latter process involves several operational challenges that put valves under severe strain, potentially causing damage and service disruptions.

The high number of open/close cycles, the extreme temperatures and the presence of particulate in the flow are some of several harsh

conditions that valves must withstand. TOVs represent an innovative solution for molecular sieving because of their design and ability to perform reliably in such extreme conditions. Using TOVs minimizes the need for maintenance while also offering significant footprint/weight reduction as compared with conventional ball valves, thus generating both Operational Expense (OPEX) and Capital Expense (CAPEX) savings.

Indeed, Emerson's Vanessa Series 30,000 TOVs have been specified and installed to replace rising stem tilting ball valves, which have been long considered the standard type of valve design for this application. Customers have ultimately found Vanessa TOVs to be effective in addressing several issues commonly encountered by industrial customers and delivering the performance required with minimum levels of maintenance and long-life expectancy.

CRACKED GAS DEHYDRATION - MOLECULAR SIEVE PROCESS

Adsorption and absorption are the two key principles used to separate molecules. The former is the most commonly used to dry cracked gases by means of hard, granular adsorbents manufactured in several types of materials including aluminosilicates (such as Zeolite), ceramic balls, activated carbon and silica gels. The latter, used on sour gas feeds, uses thin membranes and represents another application where Vanessa TOVs has gained significant experience.

Gas dehydration in ethylene production relies on the adsorption of multiple solid bed molecular sieves. Because they are made from a micro-porous material, the ability of molecular sieves to selectively adsorb gases and liquids makes them widely used across many diverse applications. Smaller diameter fluid molecules separate from the main feedstock via electrostatic attraction or micro-porosity adsorption and remain trapped inside the adsorbent structure. After use, molecular sieves are regenerated with temperature swings and regenerating gases, which allow full recovery of the trapped molecules while also restoring the sieve adsorption capacity.

Solid bed and membrane molecular sieve processes are extremely challenging for valve equipment. These processes use valves to perform frequent ON-OFF functions to switch one or more vessels from gas purification to adsorbent regeneration modes (Figure 2).

Switching valves controls the molecular sieve sequencing: one vessel in purification mode (the ambient temperature feed gas stream is flushed through the adsorbed, contaminants are separated from the gas), and the opposite one in regeneration mode (a high temperature regeneration gas is flushed in the opposite direction removing trapped contaminants). A third cooling stage may also be involved. Operating failure of molecular sieve can lead to significant plant downtime, product loss, potential environmental pollution and other safety issues.

CRITICAL ISSUES WITH OTHER TYPES OF VALVES

Gas purification valves currently face many challenges during both molecular sieve processes, three of the most significant being:

- High frequency open/close cycles – intensive cycling, the regeneration cycle may occur once every one to three hours, may cause extensive wear on the valve sealing components
- Frequent thermal cycles – typical regeneration temperatures can reach 230-315 °C (450-600 °F) and

FIGURE 1. Vanessa Series 30,000 TOV

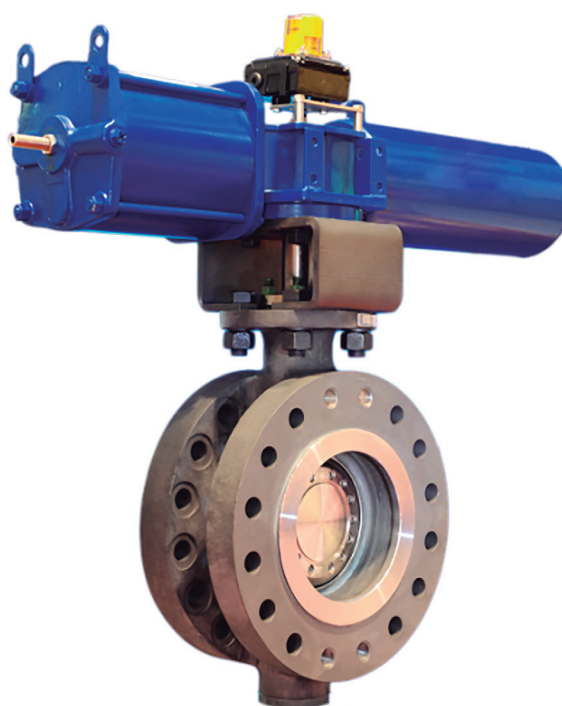
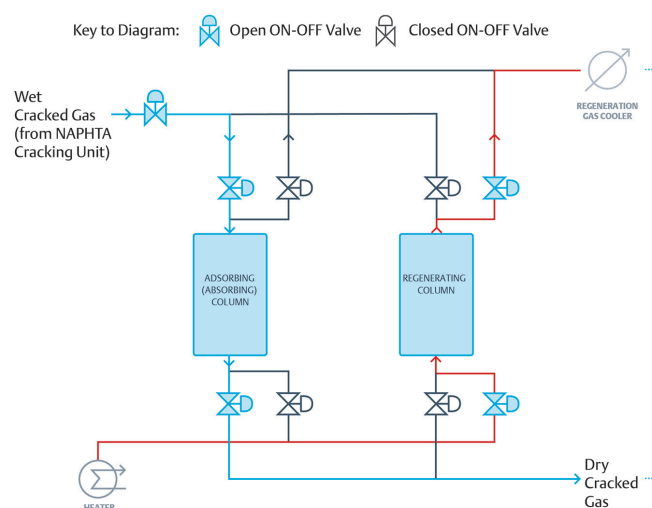


FIGURE 2. Molecular Sieve Process



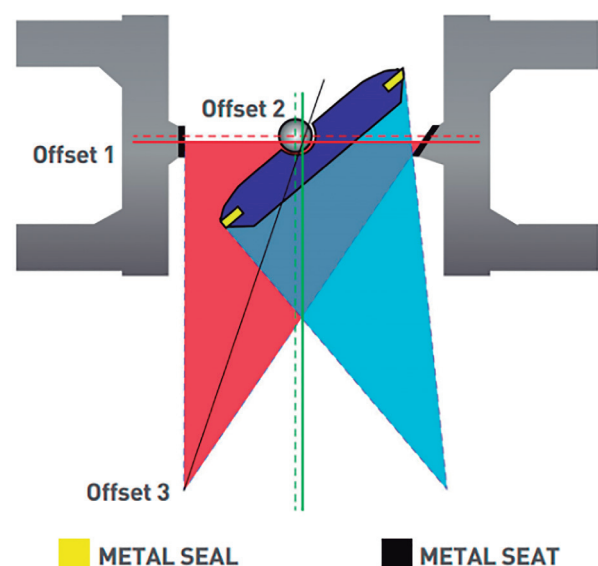
thermal expansion and contraction can affect valve performance

- Adsorbent residuals – gas purification residuals (crushed adsorbents) are often present in outlet gases and can pass through screens and flow through the valves towards downstream lines, causing abrasion of sealing components/bearings and jeopardizing valve integrity

Historically, non-rubbing rising stem (tilting) ball valves have been the standard valve design used in molecular sieves and are usually specified for sizes and classes up to 24"/Class 900. The basic design of a ball valve—a ball rotating on soft sealing surfaces with systematic rubbing—is enhanced by introducing an additional mechanical device that allows for a tilt/turn operation and a mechanical camming action of seating surfaces nearing closure. To date, this has been the most effective response from the industry for tackling the issue related to cycle-intensive applications, such as frequent switching, that would otherwise require recurrent valve maintenance or replacement.

Rising stem ball valves of larger sizes and pressure classes are extremely heavy and have a large footprint, thus generating additional material use and installation costs for which engineers must account during front-end engineering design (FEED) project phases. The tilting mechanism itself -a variant on a standard quarter-turn ball valve- is subject to wear and can degenerate over time. Although the valve sealing elements may not involve rubbing capabilities, friction is transferred to both the shaft cam (toward core pins) and the S-shaped pin slot. This valve design requires specialized maintenance which, combined with significant time and effort to be performed perform and the use of costly spare parts, massively increase the overall operational cost of the valve.

FIGURE 3. Triple Offset Design



LONG-TERM RELIABILITY OF NON-RUBBING, METAL-TO-METAL TOVS

Process designers and plant operators seeking a reliable and cost-effective option are wise to consider using a different type of valve in molecular sieve applications, such as TOVs.

The Vanessa valve was the first to provide a TOV capable of performing zero leakage¹ by using a non-rubbing design across the entire 90° rotation (differently from high performance butterfly valves which typically rub for approximately 20% of rotation) capable of delivering a single, instantaneous contact between sealing elements only when a closed position is achieved. Obviously, non-rubbing means lower wear of sealing components.

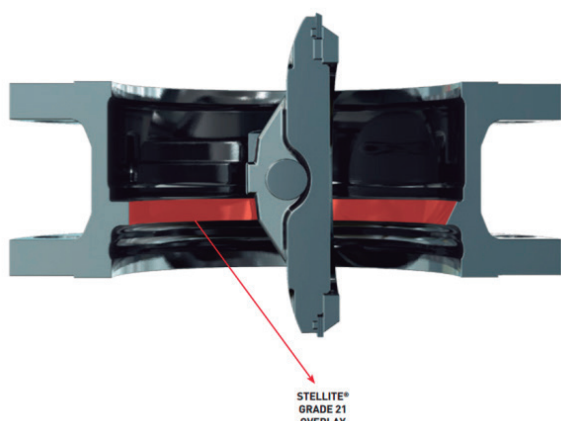
Vanessa TOVs can handle bidirectional flow and tightness in both sealing directions up to ASME class 1500 pressure due to the combination of such non-rubbing rotation with torque seating (a key difference with position seated concentric butterfly valves) achieved with three “offsets” (Figure 3):

1. The shaft is placed behind the plane of the sealing surface.
2. The shaft is placed to one side of the pipe/valve centerline.
3. The seat and seal cone centerlines are inclined in respect to the pipe/valve centerline.

On these premises, the seal ring (and not the disc itself, as is in the case of other butterfly valve designs) is the critical component as it represents the key flexible element necessary to perform sealing against a seat that is integral to the body and overlaid with Stellite grade 21. A dynamic spiral wound gasket ensures an adequate expansion and contraction of the seal ring during opening and closing.

With such flexible metal seal ring, Emerson’s Vanessa TOV design represents an innovative solution that withstands high-frequency open/close cycles. Because of the non-rubbing design, wear between sealing components is eliminated. The whole trim – which includes bearings and thrust bearings -- is customized for heavy-duty services. To protect equipment from frequent thermal and pressure cycles, Vanessa TOVs’ combination of metal-to-metal sealing, a resilient seal ring and torque seating compensate for different thermal expansion rates between trim and body while also ensuring outstanding tightness and removing the risk of valve jamming. Vanessa Series 30,000 TOVs’ Stellite 21 seat overlays offer the high resistance to wear generated by the fluid necessary to handle particulates released from the sieving vessel (Figure 4).

(1): Zero Leakage means no visible leakage when tested at high pressure with water and low pressure with air according to existing international standards.

FIGURE 4. Integral Seats with Stellite 21 Overlays

For cracked gas drying, Vanessa Series 30,000 TOVs features an easily replaceable one-piece metal solid seal ring (Figure 5) that has also proven to be effective across molecular sieve processes in a variety of other industrial applications. The material selection of each component offers the best compromise among necessary mechanical properties, corrosion resistance and equivalent expansion coefficient, making Vanessa TOVs suitable for use across an extensive range of corrosive gases, water, other liquids, and contaminants.

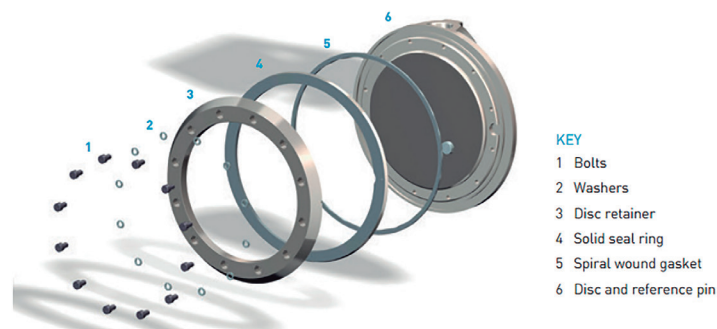
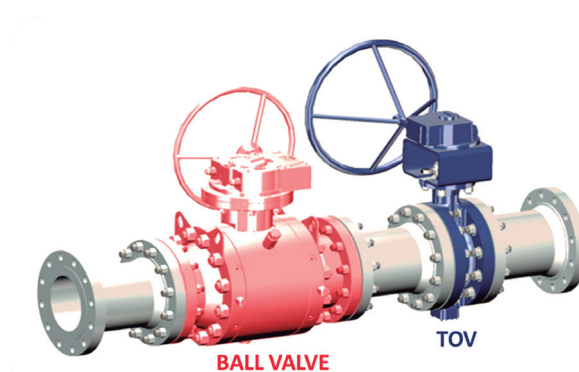
Such a cost-effective solution enables the use of a carbon steel body in a corrosive environment by protecting all surfaces in contact with the fluid with corrosion resistant alloy (CRA)-quality weld overlay.

A TREND TOWARD REPLACING OTHER TYPES OF VALVES

As noted previously in this article, rising stem ball valves can be safely substituted by TOVs. Footprint and weight savings can be achieved, especially on larger diameters (greater than 6 inches) and pressure classes (ASME class 300, 600 and above), due to lower material use and a more compact body (Figure 6).

Vanessa Series 30,000 TOVs require minimum maintenance, which can be easily performed onsite, and their non-rubbing rotation and full metal construction significantly extend the valve life. In a polyolefin plastics, polyethylene and polypropylene plant in the United Arab Emirates, several Vanessa TOVs were successfully installed in 2011 on an ethylene dehydration line cycling once per hour (14" - 44", in class 150 and 300). Several tens of thousands of cycles later, their performance is still extremely satisfactory and these valves have not been subject to maintenance thus far.

In a different type of molecular sieve application, a Pressure Swing Adsorber (PSA) which entails an even higher number of cycles (370 cycles per day), Vanessa TOVs' performance was outstanding. At the time of service, the valve had been in operation for 11 years (i.e., approximately

FIGURE 5. Solid Seal Ring**FIGURE 6.** Ball Valve vs. TOV Comparison

1.5 million open/close cycles had been carried out) and had had only packing replacements due to wear and no seal ring replacements/seat repairs.

These are just a few cases in which Vanessa TOVs have been evaluated and adopted in a molecular sieving process, which combined with 20 years of experience in oil and gas, natural gas dehydration and CO₂ removal, Air Separation Units air purification (pre-cold box) and other molecular sieving applications make specifying and installing Vanessa TOVs an outstanding solution for several customers around the world.

CONCLUSION

Emerson has earned a solid reputation as an industry leader in designing and manufacturing an exceptionally reliable valve that customers can trust for molecular sieve applications. Emerson's Vanessa TOV was the first to deliver bidirectional zero leakage performance, thus creating a new industry category by using a technology that was not previously available with other quarter turn valves. A key contributor to Vanessa's success is the triple offset design that eliminates any rubbing action of the sealing elements during the 90 degrees of rotation position. Ultimately, Vanessa TOV is a single valve solution to handle a variety of isolation and process functions with low cost of ownership, minimum maintenance requirements and long lifecycle. More than 300,000 Vanessa valves have been installed in the oil and gas, chemical, petrochemical, power and process industry sectors in virtually every region of the world. ■