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neles technical paper

Metso Automation's Valve Solutions for Delayed Coking

Our experience and extensive understanding of these severe service applications is at the heart of our long lasting solutions.

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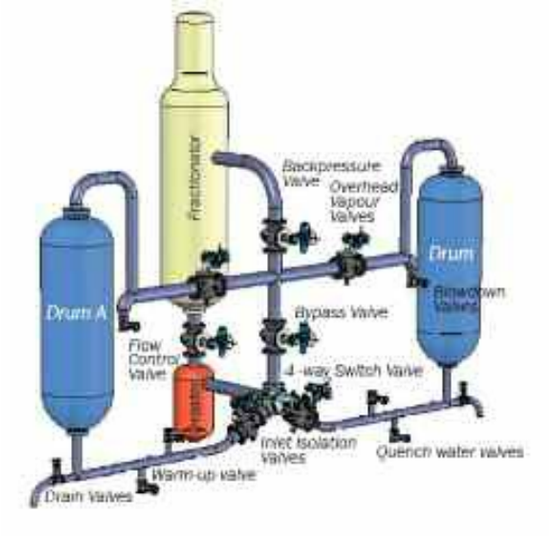
Introduction: The Delayed Coking Process

Delayed coking is a thermal cracking process in which low-value hydrocarbon feedstock is converted to lighter, more valuable products, and coke. The process involves handling a range of gases, liquids, and solids at varying pressures and temperatures up to 1000°F.

Residuum (fresh feed) enters the bottom of a fractionator where lighter material is flashed off and the remaining liquid mixes with recycled material to form the combined feed. The liquid undergoes partial vaporization and mild cracking as it passes through a coking furnace and into the coke drum. This is where the vapor undergoes further cracking and the liquid undergoes successive cracking and polymerization until it is completely converted to vapor and coke. Effluent vapor enters fractionation facilities downstream where gas, naphtha, jet fuel, and gas oil products are separated. Petroleum coke stays in the drum.



The delayed coker unit has two large vertical coker drums. During operation, one will be in coking service while the other is being decoked with high-pressure water jets. Steam removes residual hydrocarbons. The coke left in the drum is cut into fragments and carted away to coke storage or loading facilities.

Neles Delayed Coker Valves

Neles brand delayed coker 2-way ball valves from Metso Automation provide tight, bi-directional shut-off. Unlike other ball valve brands that are tight in only one direction, Neles valves operate reliably under normal or reverse pressure or flow conditions – a key requirement in the overhead vapor area where higher pressure occurs on the valve closest to the fractionator return line.

The Neles delayed coker valve's live-loaded stem packing and steam purge connection prevent residuum from leaking into the atmosphere. The steam purge design is critical to the operational life expectancy of the valves.

Because the valves are oriented horizontally in the pipeline, residuum tends to flow into the lower confines of the ball body cavity.

Neles supplies two body purge ports on every 2-way valve – one in the lower part of the cavity, and one in the upper part – to flood the cavity with steam and minimize the flow of residuum to this area. As a result, Neles delayed coker ball valves have a proven record of trouble-free operation for periods exceeding six to seven years without maintenance.

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Coke Drum Isolation Valves

After a short time in the coke furnace, heavy residuum at 510 °C / 950 °F and 4-7 bar / 60-100 psi, is charged at high velocity to the active coke drum. Downstream of the coke heater, the feed passes through a heater isolation valve, followed by the 4-way switching valve, and finally through a pair of coke drum isolation valves.

The coke drum isolation valves are required to flow and isolate in both directions. When the coke drum is active, they are open to admit the charge. When the drum is deactivated, a steam seal will be introduced into the feed line pressurizing the valve in the reverse flow direction.

The fluid that results from the decoking process is abrasive in nature. It's removed from the system through the coke drum drain valve. At the same time, the second coke drum isolation valve must isolate to prevent the back-flow of decoking slurry to the 4-way switching valve.

The Metso Automation Coke Drum Isolation Solution:

Metso Automation's solution is the MBV Series in ANSI class 300 or 600 full-port ball valve. The full-bore design is desirable because of its ability to pass the maximum amount of flow with the minimal decrease in fluid velocity and residence time inside the valve. This minimizes the tendency for the fluid stream to coke in the valve. The erosion-resistant chrome moly body (typically ASTM A217 C5 or A217 C12) is capable of providing long service life in process conditions of heavy residuum at 510 °C / 950 °F and 7 bar / 100 psi. Massive solid Stellited® seats are mechanically loaded to the ball by Inconel®718 convoluted "E" type seals.

Overhead Vapor Line Valves

Heavy residuum or vacuum residuum is heated to a temperature of 510 °C / 950 °F or greater and charged to the active coke drum. This is done at a pressure of approximately 7 bar / 100 psi. Both thermal cracking and coking occur in the drum. Light, cracked product rises to the top of the coke drum and is drawn out through the overhead vapor line. The cracked product passes through a pair of overhead vapor line valves and then on to a fractionator for separation and eventual processing. Coking also occurs as a part of the cracking process by depositing solid coke in the drum. A coke drum remains active until it is completely filled with coke. The filled drum is then taken off line for decoking and cleaning.

The Metso Automation Overhead Vapor Line Solution:

The recommended offering for overhead vapor line valves is the Metso Automation series MBV. This is an ANSI Class 300 full-port, metal-seated ball valve. Chrome moly (ASTM A217 C5 or A217 C12) is the desired material of construction. This temperature-resistant material is particularly well suited to service conditions of 400 °C / 750 °F, 4-6 bar / 60-90 psi hydrocarbon vapors. The full-bore design is desirable because of its ability to pass the maximum amount of flow with a minimal decrease in fluid velocity and residence time inside the valve. This minimizes coking in the valve. Chrome carbide coating over an A487 CA6NM martensitic corrosion-resistant cast steel substrate has a material hardness of HRC 68 to 70.

Coke Drum Drain Valves

When the coke drum in service is filled to a specific level, the fresh charge from the heater is switched to the empty coke drum. The full drum is isolated, steamed to remove hydrocarbon vapors, and cooled by filling with water. The next step in the process involves coke removal, which is accomplished with a hydraulic system referred to as a hydro-drill. A high pressure, 140-170 bar / 2000-2500 psi, water jet is lowered into the coke bed on a rotating drill. A small diameter hole is cut completely through the bed from top to bottom.

The main drill is then lowered into the hole where it cuts the bulk of the coke from the drum by impinging a high-pressure water jet perpendicular to the drum wall. The combination of solid coke, water, and steam, referred to as decoking effluent, is removed from the system through the coke drum drain valve. The fluid pressure and temperature can range from a maximum of 482 °C / 900 °F and 7 bar / 100 psi to a minimum of near ambient temperature and 3 bar / 40 psi.

Metso Automation Coke Drum Drain Valve Solution:

This is a very demanding application due to the abrasive nature of the decoking effluent. Metso Automation's solution is the series X-MBV full-port, metal-seated ball valve. The X-MBV full-bore design presents minimum restriction to flow. This minimizes the tendency for solid coke to become jammed in the body. The C12 chrome moly body material also provides excellent abrasion resistance.

Coke Feed Control & Isolation Valves

The delayed coker is comprised of four main sections; feed, coking, fractionating, and decoking. The focus here is on the feed section. Typical feed to the delayed coker is either heavy residuum drawn from the bottom of a fractionator or vacuum residuum drawn from a vacuum flash tank. Feed is preheated to approximately 371 °C / 700 °F by contact with gas oil in the fractionator. It is then mixed with recycled oil and pumped to the coke heater by the heater charge pump. The charge pump increases feed pressure from 2.4 bar / 35 psi at the exit of the fractionator to 10-14 bar /150-200 psi. The ultimate feed pressure is a function of the particular delayed coker design being used.

The Metso Automation Coke Feed Control & Isolation Valve Solution:

Metso Automation recommends the X-MBV. The full-bore metal-seated design is desired to achieve both the high flow and Class V shut-off requirements of isolation service. The series X-MBV also exhibits the high rangeability (100:1 to 300:1) required for control service. The full-bore design reduces fluid turbulence and minimizes residence time of the fluid in the valve body, while insuring the highest possible flow rate.

Technical Considerations

Construction Materials

In the Neles 4-way switching valve, the one-piece ball is manufactured of CA6NM (410SS) with a hard chrome plating on the ball. The seats are manufactured from solid Stellite® and the E-ring seals from Inconel® 718.

In all of the other delayed coker ball valve solutions (isolation, drain, blowdown, quench, overhead vapor, etc.), the CA6NM ball has a Chrome Carbide coating instead of hard chrome plating. It is our experience that the Chrome Carbide coating is much better suited to the temperature cycling of these valves in comparison to the 4-way switch valve with a hard chrome-plated ball, which remains at relatively constant elevated temperatures throughout its service life.

Our seats are manufactured from solid Stellite® and our E-ring seals are manufactured from Inconel® 718.

Testing Procedures

All of our body, body cap, and ball castings are supplied with 100% radiography (RT) using ASME B16.34 Appendix I acceptance criteria.

Body, cap, and ball castings are supplied with 100% Magnetic Particle Testing (MT) per ASME B16.34 Appendix II acceptance criteria.

All machined surfaces of the bodies and caps are Liquid Dye Penetrant (LDP) tested, per ASME B16.34 Appendix III acceptance criteria.

Visual inspection of body, cap, and ball castings will be per MSS-SP-55 guidelines.

Final Assembly

All of these valves will be assembled in the United States using components procured from various points around the world. Final assembly, testing, and inspection will be done at the Metso Automation facility in Lithia Springs, GA.

Bi-Directional Service

All Neles brand delayed coker 2-way ball valves are designed for bi-directional shut-off service conditions. Unlike other brands that are only 1-way tight, the Neles valves can operate under normal or reverse pressure or flow conditions without reservation. This is especially important in the overhead vapor area where a higher pressure condition will occur on the valves that are installed closest to the fractionator return line.

Since the bi-directional design means that there is no need for flow arrows on the Neles valves to designate from which direction the valve will reliably shut off, there is no confusion as to actuator orientation or to the orientation of the valves in the line.

Steam Purges

A constant and reliable steam supply is required for any delayed coker ball valve. It is our recommendation that each purge port has its steam supply coming directly from the steam header and not be jointly combined with other purge ports. We also recommend the use of check valves at the purge connection to prevent the accidental flow of resid into the steam system if the steam supply is ever compromised. We also recommend individually sized orifice plates to be installed in the purge lines. These are to compensate for the slight differences in purge steam pressure and volume that naturally occur when multiple drops are taken from a common feed header.

Neles delayed coker ball valves with bi-directional shut-off capability have two seats that are kept tightly pressed against the ball, regardless of the pressure and its origin, through the use of an E-seal that has been proven in operation in numerous delayed cokers throughout the world. It is important to keep steam circulating throughout the E-seal and consequently there are two inside E-seal purge connections and two outside E-seal purge connections.

Our stem packing is live-loaded with a steam purge connection that prevents the travel of resid through the packing to the atmosphere. Given the 2-piece ball and stem design utilized on the Neles 2-way coker ball valves, this packing design is perfectly symmetrical and has no forces from within the valve trying to angularly deflect the stem and compromise the ability of the packing to seal tightly. The stem packing system serves the dual purpose of preventing shaft leakage while directing purge steam through the shaft bearings.

The ball and body cavity purges are especially important to the operational life expectancy of the valves. As the ball on a 2-way coker valve rotates from open to closed (or closed to open), the resid that is contained in the port of the ball has a natural tendency to flow into the lower confines of the ball body cavity. Since most 2-way coker ball valves are installed in a horizontal pipe with the valve stem in the vertical up position, this means that the resid will flow into the area of the body below the ball. In order to prevent this, purge steam, at a higher pressure than the feed pressure, occupies the ball cavity preventing the accumulation of charge in the valve body cavity.

As the valves associated with the drum being prepared for drilling cool from the temperature they had reached with resid flowing through them, any resid that is allowed to enter the lower area of the valve will harden and ultimately cause an increase in turning torque. Body purges are intended to minimize the collection of resid in the lower body cavity. Neles supplies two body purge ports on every 2-way delayed coker ball valve; one in the upper part of the cavity, and one in the lower part of the cavity. In comparison to other manufacturers, who only supply one body purge in the upper part of their valve, the Neles design floods the cavity with steam and minimizes the flow of the resid to this area.

Knowing that steam requirements are a concern, the actuators on the Neles 2-way ball valves are sized to rotate the valves quickly from full open to full close. Typically, all of the stroking times on any size of 2-way valve are under one minute, which means that a minimal amount of steam will be used to keep the accumulation of resid under the ball to an absolute minimum. This design has been proven at installations where Neles 2-way coker ball valves operate trouble-free for periods exceeding six to seven years with zero maintenance.

About Metso Automation

Metso Automation specializes in automation and information management application networks and systems, field control technology and life cycle performance services. Its main customers are power, energy, and oil and gas industries as well as the pulp and paper industry.

With almost 3,600 employees, Metso Automation operates worldwide through sales and customer support units in 35 countries across Europe, North and South America, Asia and Africa. In 2007, Metso Automation's net sales were EUR 698 million. www.metsoautomation.com

Metso Automation, Flow Control

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