Originally appeared in: January 2009, pgs 71-72. Used with permission. HYDROCARBON PROCESSING®

Developments in metal-seated valves for severe-service applications

The most recent design emphasis has been on protecting or removing the seats and seating members from direct impingement by particles in the flow stream

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Significant advancements in metal-seated valve technology have occurred in the past decade as answers have been sought for challenging applications within a variety of industries—oil and gas production, refining, petrochemical, power generation, mining, and pulp and paper. "Severe services" are typically those that are abrasive, high temperature and/or corrosive. Metal-seated valves are used in all of these industries and are often associated with severe service.

Severe-service applications. Oil and gas production fields often produce oil, gas or multiphase fluids with entrained sand that damages the seating surfaces, closure members and body walls of most traditional design on-off valves. North Sea production facilities have been faced with this challenge for several decades. Offshore eastern Canada, Australia, the Middle East and many other major oil or gas developments face this expensive factor in maintaining production. Metal-seated valves are often chosen to help address seat leakage concerns.

Heavy oil technology in various parts of the world, including western Canada, often required metal-seated valves for challenging oil sands production, handling and processing. Knife gate valves have long been the standard for this application. Other valve designs are being used, dependent on the abrasion severity and erosive nature of the fluid stream.

The gas processing and refining industries require valves that must stand up to various catalysts, silica gel, molecular sieve and coke fines. And often, the service is also high temperature or temperature cyclic in addition to abrasive. This combination of factors clearly falls within the scope of severe service. Due to temperature specification alone (above 230°C), metal-seated valves are chosen.

Steam applications in both refining and power plants require metal-seated valves. Some chemical manufacturers require metal-seated valves to assure compatibility with the chemicals that are being handled. The conclusion is that metal-seated valves are required in various industries for shutoff of fluids in abrasive or high-temperature applications.

Metal-seat hardfacing and coating technology. The downside of metal-seated valves has been the inability to provide a repeatable leak rate acceptable for the specific application or the inability to provide seats resistant to abrasive wear and impingement by particulates, fines and other solids entrained in the process stream. Technical advancements have occurred in hard-facing and coatings. Cobalt-based overlay materials are often used for abrasion resistance. New metallurgical developments have yielded improved abrasion-resistant cobalt-based overlay alloys that also provide enhanced corrosion resistance. Tungsten carbide has long been used for improving seating surface hardness, and recently proprietary ultra-hard tungsten carbide versions have found a place in the industry. Nitriding and molten salt bath ferritic nitrocarburizing are used. Depending on a variety of factors, boron carbide and ceramic coatings have proven successful. There are appropriate selections of hard-facing or coating for almost any environment.

The choice of which hard-facing or coating is used is determined by the propensity for damage by direct impingement, potential for abrasive wear due to fines, hardness requirement, corrosion and even thermal cyclic considerations. Consideration to bearing properties and the substrate material and geometry must be considered. Availability and price of the particular hard-facing or coating from the valve manufacturer are important considerations in specifying or purchasing valves for severe-service applications.

Removing seating members from flow. Choosing a metal-seat design is only the first step in selecting an appropriate valve for abrasive or otherwise severe service. This is only addressing one particular aspect of the severe service. Hard-facing and coatings simply provide resistance to abrasion and impingement of the sealing surfaces. Even some of the newest, hardest technologies cannot withstand constant "sandblasting" and seat impingement. Therefore, the most recent valve design emphasis has been on protecting or removing the seats and seating members from the flow stream while the valve is open and minimizing the impingement of particulates, fines and other solids during the valve cycling (opening and closing of the valve).

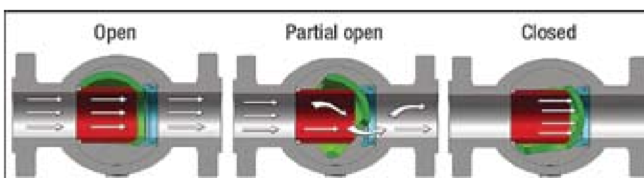

FIG. 1 Hemispherical wedge valves use a tapered hemispherical-shaped closure member that rotates around a fixed core and mechanically wedges into a metal seat to provide tight shutoff.

FIG. 2 The cartridge may be removed by unbolting the bonnet fasteners and lifting the cartridge from the valve body.

Most conventional valve designs (ball, plug, gate, butterfly) allow the service fluids to be "directed" at the seat during valve opening and closing. A recent addition to the valve industry, hemispherical wedge valves, protect the sealing surface during valve operation. Hemispherical wedge valves use a tapered hemispherical-shaped closure member that rotates around a fixed core and mechanically wedges into a metal seat to provide a tight shutoff (Fig. 1). The hemispherical wedge acts like a gate in that it moves into the flow stream to provide shutoff. In the full-open position, the seats are protected by the hemispherical-shaped closure member. Since the "gate" is hemispherical in shape, the valves are operated with a lever, gear or low-profile actuator like a ball valve rather than linearly like a gate valve.

Directing flow away from seat and body. Another significant aspect of the hemispherical wedge valve design is that only the hemispherical closure member moves into the flow stream. A ball valve has a "ball" (or "core") that rotates within the flow stream. As the ball rotates, the flow is directed at the seat. The flow is sometimes also directed at the side of the body, which can result in body wall erosion. The core within a hemispherical wedge valve is fixed and aligned with the body bore and flow stream, directing the flow through the opening area between the hemispherical wedge and the body. Particulates, fines, or other solids are directed through the valve with minimal turbulence and little or no direct impingement on the seats or even the body wall. Also, in high-flow applications, rotating a ball or core against the flow will increase dynamic loading within the valve, which can result in a marked increase in required force to operate the valve.

The hemispherical wedge valve design provides a mechanical seal due to the wedging action of the hemispherical closure member rather than a position seal like most metal-seated ball or plug valves. The seats are loaded only in the final closing action of the valve. The mechanical sealing assures shutoff at both high and low differential pressures. Factory acceptance testing of a hemispherical wedge valve includes closure testing to ISO 5208 Class Rate A for 4-in. bore size and smaller and Rate B for 6-in. bore size and larger.

Replaceable trim cartridge. Another facet of the hemispherical wedge valve design is that it can be provided with a replaceable cartridge. The cartridge consists of all the valves' internal parts (core, hemispherical closure member, seat, stem and bushings) affixed to a bonnet. The cartridge may be removed by unbolting the bonnet fasteners and lifting the cartridge from the valve body (Fig. 2). A new pretested cartridge may then be installed without removing the valve from the line. Despite appropriate selection of hard-facing or coatings and protection of seats, severe-service valves may still require routine maintenance. The replaceable cartridge provides a means of quickly and easily installing new trim with no special tools, minimizing downtime. The cartridge pulled from service can then have seats or hemispherical wedge closure members replaced on site with no special tools so that a spare cartridge can be maintained at the site for the next service—planned or unplanned. For valves that are welded-in or have insulation, this replaceable cartridge feature provides significant maintenance cost and operational savings due to minimal downtime.

Extended body for remote access. Offshore facilities, tightly configured skids and hard-to-access locations requiring metal-seat or severe-service technology may benefit from the use of hemispherical wedge valves. Besides having a low profile (similar to quarter-turn ball valve with a quarter-turn actuator), another unique aspect of hemispherical wedge valves is the body may be extended to permit trim (cartridge) replacement without physically having to be in the immediate area around the valve. **HP**

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