Geothermal Power – New Ball Valve Technology Pays Dividends

ABSTRACT

Although geothermal energy generation is a growing renewable resource, it still presents challenges for equipment suppliers in controlling the often harsh geothermal fluids. A geothermal plant can use direct steam, hot water, or a mixture of steam and water but in all cases, the fluids can contain abrasive and corrosive chemicals and minerals that can foul, erode, and damage control valves (Atlason, 2014). For many years, through-conduit slab gate valves have been employed to isolate the well heads in the aforementioned services. But in recent years QuadroSphere® trunnion ball valves have proved to offer unique features that make them an excellent choice for hot water (geothermal brine) services.

Valves for Geothermal Brine Service

The Coso Geothermal Field, situated northeast of Bakersfield, California, consists of four power plants. Construction began in the 1980's and today there are 80-90 operating production wells feeding the power plants, which utilize double-flash technology for steam extraction. In this process, geothermal fluid is sprayed into a separator tank held at a low pressure, causing some of the fluid to rapidly vaporize into steam. The steam then drives a turbine and generator. The remaining liquid is flashed again in a second tank (double flash) to extract additional energy (Figure 1).

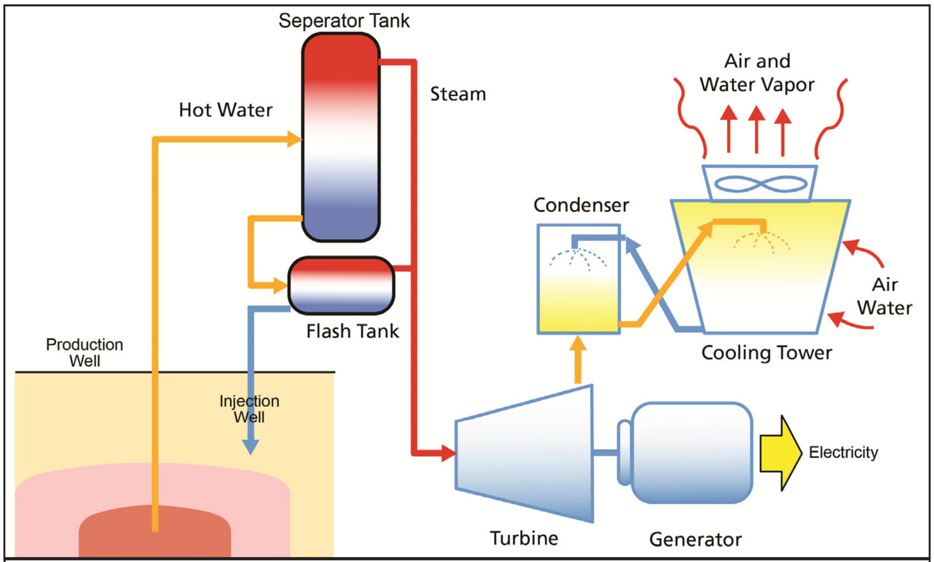

Figure 1. Typical Double Flash Geothermal System

The wellhead pressures at Coso can range up to 3500 kPa (500 psi), with temperatures reaching 260° C (500° F). The fluids produced are moderate saline chloride brines with total dissolved solids from 7,000 to 18,000 ppm, similar to brackish water with sediment. As is the case in many geothermal fields, the wellhead valves are through-conduit slab gate valves which have been used for many years even though they require regular repair and maintenance due to leakage caused by sand erosion and calcium carbonate mineral deposits in the seating areas of the valves.

The Salton Sea area in California is also home to several power plants that successfully employ geothermal brine as their source of energy. ORMAT Geothermal operates plants at East Mesa and Brawley, where the brine wells produce a hot fluid containing total dissolved solids (similar to sea water) plus sand and trace minerals, which cause a significant amount of salt build-up to occur in the wellhead valves and piping. The severe and aggressive nature of this geothermal brine together with the pressure and temperature conditions encountered at the above geothermal fields cause a concrete like build-up of scale and calcium, thereby prohibiting the use of traditional trunnion ball valves in brine withdrawal and re-injection services.

The Success of the QuadroSphere® Trunnion Ball Valve

In 2007, several of the production and re-injection wells at East Mesa, Brawley, and in the Northern Nevada geothermal fields, were successfully fitted with 10 NPS Class 150, 12 NPS Class 400, and 16 NPS Class 600, peek-seated QuadroSphere® trunnion ball valves (Figures 2 and 3). These full-port QuadroSphere® valves were manufactured to the forged trunnion ball valve requirements given in ASME B16.34 and API 6D valve standards. Their unrestricted flow path provided increased flow and less turbulence, thereby, the valves were less susceptible to the build-up of mineral deposits and prevented fouling and wear of valve internals.

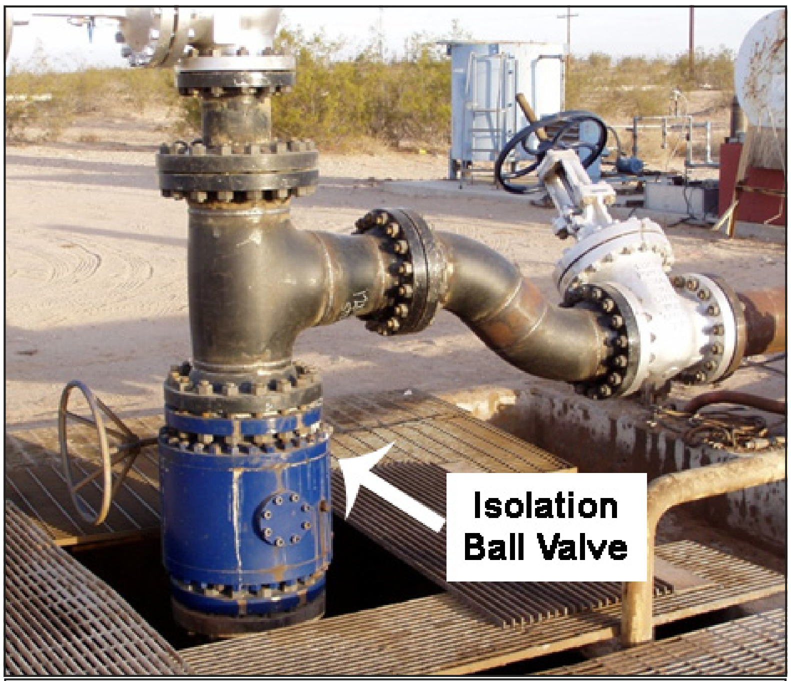

Figure 2. QuadroSphere® Ball Valve at Wellhead

Figure 3. 16 NPS Class 600 QuadroSphere® 16-3/4 in. Bore Brine Well Master Valve Valve at Wellhead

QuadroSphere® Ball Geometry

The QuadroSphere® ball valve is well-suited for geothermal brine service due to its unique ball geometry. As illustrated in Figure 4, all of the non-essential surfaces of the ball are recessed. The remaining spherical surfaces on the ball form a raised sealing surface in both the open and closed positions, which protect the valve sealing surfaces whenever the valve is in the fully open or closed positions. In a traditional ball valve, the ball would be spherical on the closed ends of the ball causing it to be in constant contact with the valve's seats during operation. However, during its operation the edges on the QuadroSphere® ball's four raised seating areas clean and wipe scale and debris from the seating surfaces and into the recessed areas on the ball, which do not contact the seats when the ball rotates.

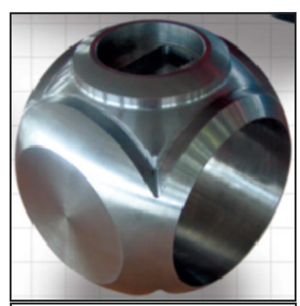

Figure 4. Unique Contoured Ball with Edges That Provide Cleaning

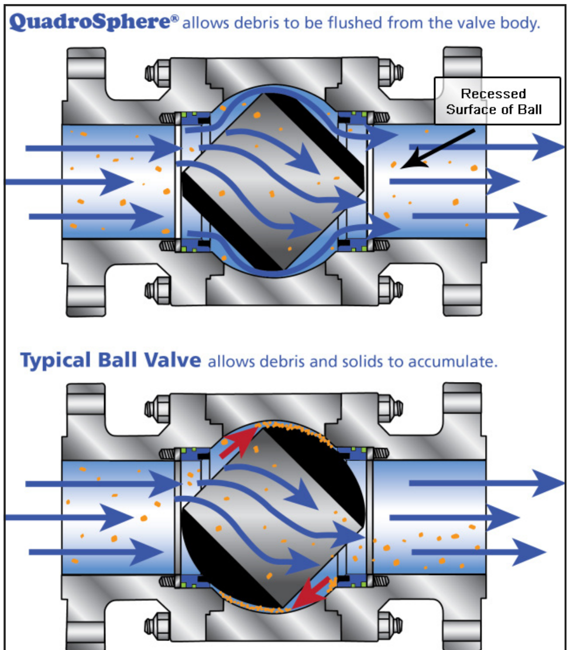

Figure 5. Flushing action of the QuadroSphere® Ball Valve

During operation, the QuadroSphere® also provides additional flow paths for the fluid, and any particulates, to flush from the inner body during operation. This cleaning and flushing occurs whenever the QuadroSphere® ball is moving from the closed to open position (Figure 5). Additional benefits are realized from the QuadroSphere® technology because the approximately seventy percent less ball-to-seat surface contact area reduces not only seat wear, but also the valve's running torque. For increased wear resistance, the stainless steel ball is hard-chrome plated. The result is a self-cleaning, severe service, resilient seated valve with the longevity of a metal-to-metal seated valve.

Positive Seat Seals

Similar to traditional trunnion ball valves, the QuadroSphere® trunnion ball valve provides bi-directional resilient sealing. The metal seat rings float axially in body recesses called seat ring pockets and are pre-loaded by compression seat springs. The metal seat rings react to the upstream line pressure to seal tightly against the ball. As shown in Figure 6, under low pressure conditions, the compression springs provide an initial sealing force to the back of the metal seat ring. Then, as line pressure is introduced into the annular area between the seat O-ring and the seat insert, a pressure force develops, which holds the resilient seat insert against the ball to create a tight seal. Resilient seat ring inserts can be made from various plastic-based compounds including glass-filled or carbon fiber-reinforced polytetrafluoroethylene (RPTFE).

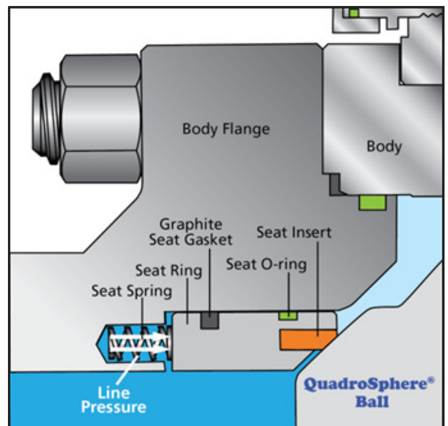

Figure 6. DBB Seating Action

Double Block & Bleed (DBB) Seating

Like conventional trunnion ball valves, standard configuration QuadroSphere® Ball Valves are equipped with a seat on each end of the valve to provide Double Block and Bleed (DBB) function and provide independent isolation of flow coming from either side of the valve. In the event the inner body cavity pressure exceeds the line pressure plus the spring force on either seat ring, the valve seat ring will automatically move away from the ball and bleed fluid back into the pipeline and prevent any possibility of a potentially damaging overpressure condition inside the body chamber of the valve.

Forged Construction

The well-proven platform from which QuadroSphere® valves are made consists of an API 608 three-piece, forged body with upper and lower bonnet plus forged seat rings and stem. The benefits of forged construction include the elimination of porosity and cracks that are sometimes associated with cast products. The secondary heating and forming processes that go into making forged components add further grain structure realignment, thereby providing additional structural integrity to the part (Johnson 2015). Moreover, the forging process ensures superior surface finishes and eliminates the need for weld repairs.

Ease of Actuation

Because QuadroSphere® trunnion ball valves require just ninety degrees of rotation to go from open to closed, they can be equipped with a variety of quarter-turn actuators, including manual gear, pneumatic, electric, hydraulic, and electro-hydraulic types for remote or automatic operation. For instance, a gear actuator which multiplies the hand wheel torque many times over enables a typical QuadroSphere® valve to be operated with a torque of about 200 N-m, while some stem driven slab gate valves may require three times that amount to achieve a tight seal. Gear actuators are also easily adaptable for an electric motor or automatic operation.

Summary

By incorporating the advanced design features of the QuadroSphere® trunnion ball valves, several geothermal facilities have gained improved valve performance and overall system reliability, while reducing maintenance frequency.

References

Atlason, Reynir S. and Runar Unnthorsson, "Wellhead Scaleing Problems in Geothermal Power Plants Addressed Using a Needle Valve Derivative," Proceedings of the ASME 2014 Power Conference.

Johnson, Greg, "Forgings: Higher Quality with a Cost," Valve Magazine, Winter, 2015, pp.38-40.

About the Author

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