Hardened Reactive Metals Drive Innovation

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Metal-seated ball valves used in highly corrosive or erosive applications must be able to withstand challenging operating environments. Zirconium, titanium, and other reactive/refractory metals are extremely corrosion-resistant and are often used by valve manufacturers to design valves for applications involving sulfuric, hydrochloric, and acetic acids.

Reactive/refractory metals are relatively soft materials that often gall or are easily damaged in applications that require metal-to-metal seating with significant dynamic contact. Applied coatings can be employed to produce surfaces resistant to wear and gall. However, coatings can introduce materials that might not have sufficient corrosion-resistant properties for the application, as well as have issues with cracking, delamination, and porosity. Other methods for surface hardening provide results that are too variable for practical application to precision valve parts.

The Use of Refractory Metals in Valve Design

When processes require equipment that can handle the most demanding, corrosive or erosive fluids, valves constructed of refractory/reactive metals are often the answer. These metals comprise a class of materials extraordinarily resistant to heat, wear, and corrosion and include:

- Tungsten
- Tantalum
- Zirconium
- Titanium
- Niobium

- Molybdenum

Refractory/reactive metals are characterized by their extreme melting points (above 1850ºC) — well above those of iron and nickel commonly used in ball valve applications. Metals such as tungsten and molybdenum are commonly used in applications from light bulb filaments to strengthening alloys for steel, and valve designs commonly use zirconium, titanium, niobium, and tantalum for their specific corrosion-resistant properties.

The interesting feature of these materials is that when exposed to air, the outer surface quickly oxidizes, forming stable, protective and self-healing oxide films that are extremely resistant to corrosion. In fact, these metals have such an affinity for oxygen that they must be melted in a vacuum, as they will burn if heated in air. As a result of this oxide outer layer, this group of metals exhibits excellent corrosion resistance in a variety of extreme chemical applications with little to no corrosion rate.

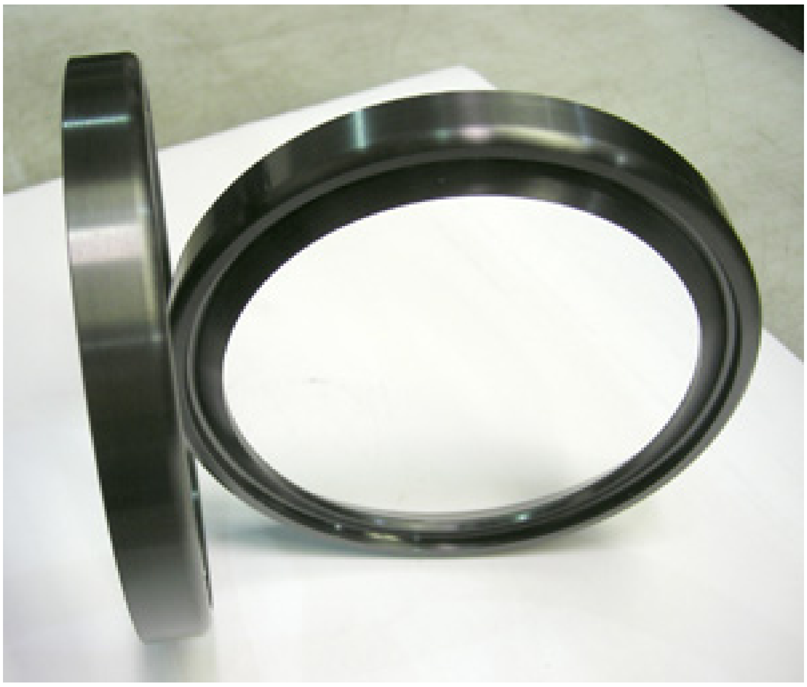
Traditionally, when using more common metals for metal seated ball valves, coatings were used to accommodate sealing. The challenge when going to a reactive/refractive metal was finding a method to surface harden these materials for use on a flexible metal seat in the finished machined condition. Applied coatings proved too stiff, had too little corrosion resistance compared to the reactive metal or created unacceptable dimensional changes in the finished part.

When a suitable solution could not be found via traditional means, a new method was developed to create the desirable oxide layer — strengthening or hardening it enough to support dynamic metal-to-metal contact.

Fluidized Beds & the Hardening Process

Fluidized beds have been used in the past for various metal treatment processes including oxidizing and nitriding. The advantages of the fluidized bed include:

- More uniform heat transfer than in an air furnace.
- Creation of an inert atmosphere by fluidizing with inert gases at much lower volumes than that required by a normal, controlled atmosphere furnace.
- Controlled rates of heating and cooling by cycling the fluidization.
- Easy, independent control for precise mixtures and volumes of desired gases to oxidize or nitride.
- Fluidized-bed materials that are inert to the workpieces and the injected gases.



The Flowserve hardening process uses the precision time and temperature capabilities of fluidized bed heating and controlled atmosphere to produce a hard, uniform case on reactive/refractory metals. Extensive testing improved the process, which determined the optimal amounts of fluidizing and process gases needed, as well as the process temperatures required, to improve the hardened oxide layer on zirconium.

Zirconium oxide (zircon sand) was chosen as the fluidizing media due to its high refractory properties, resistance to thermal cycling and availability; its use eliminates any potential oxygen diffusion into the workpiece. Fluidizing the media with a slow, uniform gas flow produces a liquid-like state that enables workpieces to be inserted and removed with ease. The fluidized media performs many functions, transferring heat to the workpiece, cooling the workpiece when the heat source is removed, or, if fluidization is stopped, can insulate the workpiece.

Enabling Innovation

The development of fluidized bed hardening techniques for reactive-refractive materials, such as those discussed above, can enable manufacturers to support new applications that span industries ranging from chemical to aerospace. Some examples include:

- Surface hardening pistons for hydraulic flight control valves, eliminating a dry film lubricant.
- Surface hardening reactive/refractive fasteners, allowing disassembly and reuse without galling.
- Reactive/refractory hardened sleeves for pump shaft seal sections, increasing service life by reducing shaft wear.
- Hardening of a titanium GR 5 hydraulic servo housing for the space shuttle robotic arm.

Without the development of the fluidized-bed hardening process, products serving these applications would not be as reliable and would increase the cost to operate and maintain.

However varied the applications, the specific characteristic of the hardened material that enables each is the same: high surface hardness on these extremely corrosion-resistant metals to protect them from galling and wear without altering their desirable properties or the dimensions of the finished parts.

Fluidized bed hardening has allowed engineers to continue to push the envelope in process design by venturing into new, previously impossible, applications for process valves. Innovation leads to increased process efficiency, which reduces overall cost.

For more information, please visit www.flowserve.com *[1].*

Links:
[1] http://www.flowserve.com/