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KCP&L INCREASES PLANT CAPACITY BY RETROFITTING NEW CONTROL VALVES

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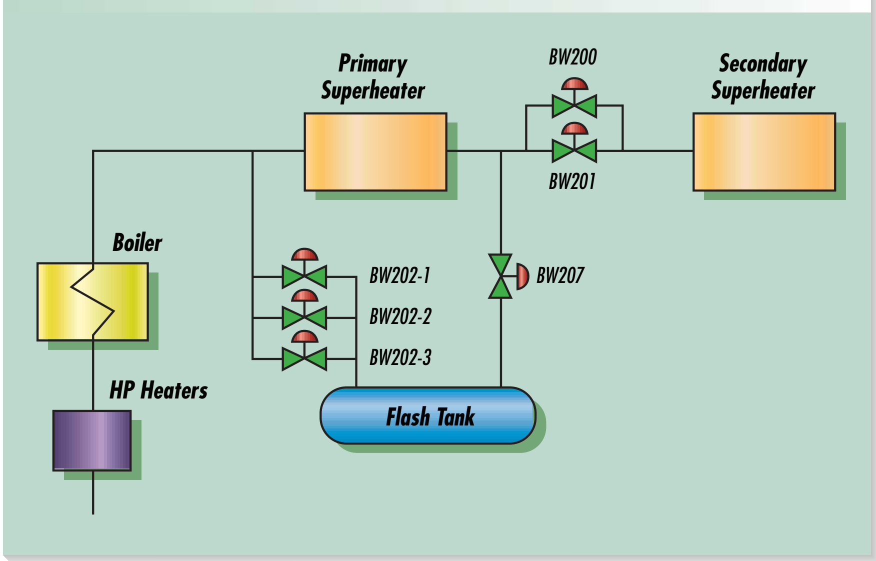
Many power plants use older control valve technologies that do not address the severe nature of today's power plant operations. The older design valves require constant maintenance and their performance is generally poor. In addition, leaking control valves can reduce a power plant's output by up to 50 MW.

Modern generating plants require that control valves provide both control and shutoff functions. Not only does this dual role reduce capital expense, it also addresses the complexity of many control algorithms. Providing tight shutoff and control in one valve rather than two valves eliminates the need for two sets of logics to be embedded into the control system. These valves are also expected to maintain long-term shutoff without leaking.

With control valve improvement opportunities in mind, Kansas City Power and Light (KCP&L) investigated the potential advantages of replacing the BW202 and BW207 valves on the once through supercritical boiler on Unit 1 at their 750 MW LaCygne power plant.

Although the original valves were designed to withstand high pressure and high temperatures, they invariably failed to provide long lasting shutoff. Additionally, the valves' body and trim components leaked, requiring continual maintenance. Initial estimates indicated that four valves (three BW202s and one BW207) accounted for a loss in capacity of 10 to 12 MW from valve leakage alone. Further investigation revealed that the lost capacity could climb as high as 18 MW if nothing was done to rectify the leaking valves.

FIGURE 1
STARTUP VALVE SEQUENCE SCHEMATIC



VALVE APPLICATION

When the BW202 and BW207 valves operate in a baseload configuration, they are required to bring a supercritical power plant (operating at pressures above 3,650 psig) from initial startup through 25 percent plant load. A cold startup general requires 8-12 hours versus one to two for a warm startup.

The BW202 valves, the primary superheater bypass valves, route flow around the primary superheater to a flash tank, Figure 1. As the plant startup begins, these valves circulate cold water through the boiler to the flash tank until an outlet pressure of 600 psig is reached at the primary superheater.

With the inlet pressure to the valves at approximately 3,800 psig, and the flash tank being under minimal pressure, cavitation during this mode of operation is inevitable. Cavitation, the formation and subsequent collapse of vapor bubbles in liquid flow streams, is a major source of damage for control valves and adjacent piping.

Once firing is initiated in the boiler, the outlet pressure at the primary superheater ramps from 600 psig to 3,650 psig. At this point the BW202 valves are set to maintain 3,650 psig at the primary superheater outlet. When this occurs, the BW207 secondary superheater bypass valve begins to open to maintain primary superheater outlet temperature. Similar to the BW202 valves, the BW207 valve also experiences cavitation during initial operation.

As the primary superheater's pressure and temperature increase, the flash tank pressure also increases. With the rise in temperature comes the possibility of the pressure in the flash tank being below the vapor pressure of the incoming hot water. If this happens flashing will occur inside the BW202 and BW207 valves and cause extensive erosion of the valve's internal components.

Once the flash tank reaches 1,000 psig, the BW201 valve opens, admitting steam to the secondary superheater. The BW201 controls the pressure to the secondary superheater as the BW202 and BW207 valves begin to close, thus maintaining the pressure and temperature in the primary superheater.

At this point, superheated steam passes through both the BW202 and BW207 valves. Once the plant's load reaches 25 percent capacity, the BW202 and BW207 valves close completely. These valves remain closed and operate only as relief valves to dump main steam to the flash tank if the operating pressure exceeds 4,250 psig.

The BW202 and BW207 valves must withstand cavitation, flashing and superheated steam. However, to accomplish this requires a valve with a body and trim combination that is able to control cavitation and protect against flashing damage. They also must minimize noise and vibration while processing the superheated steam.

VALVES REPLACED

KCP&L engineers evaluated several valve replacement options before specifying 8-inch ANSI 2500 Fisher globe valves equipped with Cavitrol III trim, The Cavitrol III trim, which is a cage-style, controls cavitation by staging the pressure drop as the steam passes through the cage wall. Transitioning from large pilot holes to small pilot holes ensures that the boundary layer of the fluid does not separate before it reaches the outlet of the valve. By gradually decreasing the minimum flow area, the overall effective pressure recovery is minimized. This results in more uniform velocities at the cross section of each pilot hole than is typically seen in tortuous path valve designs.

The staged design of the trim helps to eliminate the damaging effects that can occur as the inlet temperature increases and flashing takes place. By properly designing the staging effects through the trim, any flashing that does occur will be at the outlet of the last stage in the trim. The flashing fluid is directed into the center of the valve trim and away from any metal components, thus avoiding flashing damage to the valve and its components.

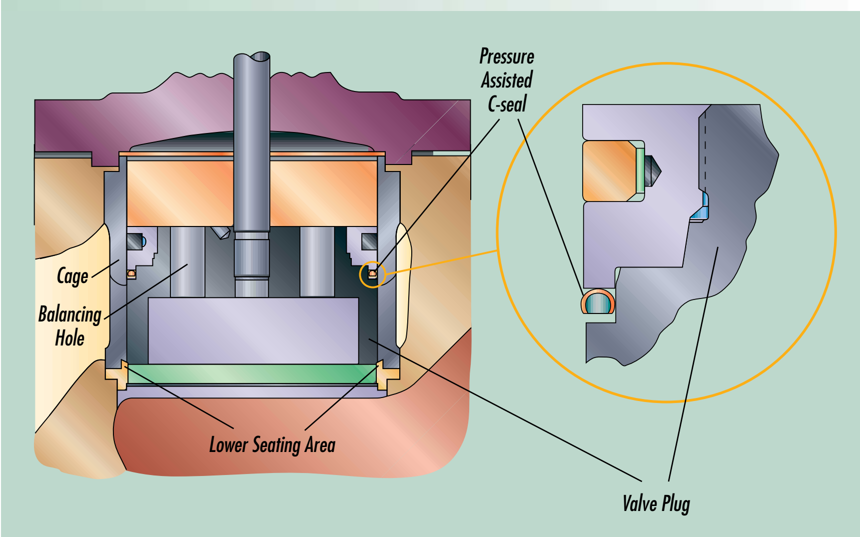
Given that the BW202 and BW207 valves will see a wide range of pressures and temperatures, the valve's trim must be able to withstand pressures up to 4,250 psig and temperature up to 805 F. In the high temperatures control valves used at the LaCygne plant, the cage has a lip machined in the upper portion. This design allows the trim to hang between the body and the bonnet connection areas.

A hung style trim negates the effects of thermal expansion at high temperatures. With a hung style gage, expansion occurs axially. As a result binding between the plug and the cage is eliminated. A sealing mechanism in the valve eliminates leakage between the cage and seat ring. The cage and the seating ring are bolted into the valve's body.

For many years, KCP&L used valves with pilot balanced trim with internal plugs. Unfortunately in operation these valves can become unbalanced and cause the plug to slam shut. As a result, performance, maintenance and leaking of the valves were continual problems. Because of this, KCP&L required that any replacement valves would have to be reliable, maintenance free and provide extended shutoff. The new valves also would have to reuse the plant's existing electro-hydraulic actuation system.

FIGURE 2

C-SEAL TIGHT SHUT-OFF TRIM



Besides being used as a control valves they are also used for shutoff. Because CP&L required a leak free shutoff , a Fisher design C-seal tight shutoff trim was installed in combination with the Cavitrol trim to provide ANSI Class V leakage protection, Figure 2.

The C-seal trim design employs multiple metal-to-metal sealing arrangements with a balanced valve plug. The upper seal, which is pressure-assisted, is positioned immediately above the top flow passages and the cage wall. This eliminates the flow between the upper cage and the valve plug. Once the seal makes contact with the upper seat in the cage, the actuator continues to stroke until contact is made between the valve plug and its seat ring.

The combination upper seal and valve plug seat design provides the level of shutoff typically seen with pilot balanced trims. However, it eliminates the setup and maintenance that the pilot type devices require.

PLANT PERFORMANCE IMPROVES

After installing the four new valves KCP&L saw an immediate improvement in plant performance. This included increased capacity and efficiency and reduced maintenance costs. Prior to installing the new valves the flash tank was operating at over 600 psig. Since installation of the new valves the flash tank pressure has remained constant at 150 psig. Leakage past the BW205 valve, however, is still a problem. Once this valve is replaced, the flash tank pressure is expected to drop further.

In addition to reducing the flash tank's pressure, the feedwater pumping load has also been reduced by 10 percent. Assuming the cost to operate the pump is $0.02/ kWh, an annual savings of $275,000 in excess pumping costs is possible.

Since the startup valve upgrade, the plant's capacity has increased by 15-20 MW. This, in combination with several other modifications, has enabled the plant to reduce the overall heat rate by four percent, thus saving the plant $4 million dollars per year. As shown by the KCP&L experience, valve leakage can have a huge impact on the bottom line of a power plant. PE