Keeping Control of Drum Levels

By Joe Zwers, freelance writer

Power plants are designed to operate for decades, provided they undergo regular repair, upgrade and improvement. Much of the time, those maintenance actions are minor. But plant managers expect a few big-ticket expenditures.

Public Service Electric & Gas Co. (PSEG), for instance, spent $1.3 billion and more than 7 million hours of labor during the 2008 to 2010 period upgrading emissions controls at its Hudson and Mercer, N.J. coal-fired plants. By installing scrubbers, selective catalytic reduction, baghouses and activated carbon injection, PSEG reduced NO_X emissions by more than 95 percent, SO_2 by more than 94 percent, particulates by more than 99 percent and mercury by more than 90 percent.

On a smaller scale, PSEG's 753 MW Mercer Generating Station experienced problems controlling the water levels in its four Foster Wheeler drum boilers. In that case, it was simply a matter of replacing the original actuators on the feedwater valves with new electraulic actuators.

"We would have excursions in drum levels and had to wait until it settled down before the operator was comfortable with moving on line," said PSEG Controls Engineer, Mark Maute. "It's not a problem anymore. There is no slop in the controls and it runs right where it is supposed to."

Hitting the Set Point

Boiler efficiency and overall plant performance depend on being able to accurately control the water levels in the drum. Several problems affect that ability.

To begin with, there is the issue of shrink and swell. As steam demand increases, the drum pressure drops initially, causing bubbles to form below the surface of the water and producing a rise in the drum level (swell). When demand decreases, pressure in the drum increases and water levels drop (shrink). This is usually addressed by using a cascade/feed-forward control strategy that takes readings from steam flow, feedwater flow, drum level and drum pressure transmitters and adjusts the feedwater accordingly.

The feedwater control strategy must also integrate with the combustion control strategy. The firing rate set point demand is calculated as a function of the steam flow and the main steam header pressure. Accurate control of the feedwater loop is necessary to maintain stable combustion flow. If the plant requires steam pressure and flow to remain fairly constant but the feedwater loop is unstable due to poor controllability, the combustion controls will have to continually adjust in attempting to follow unstable changes in the feedwater flow and keep the steam demand at the set point.

To accurately control the volume of water entering the drum, the feedwater regulator valve needs to accommodate a wide range of operating conditions. During start-up and low-fire conditions, the valve sees high inlet pressures but low flow, so the valve requires anti-cavitation trim to address the full pressure drop across the valve. As the boiler load increases, the valve passes more flow, the inlet pressure drops and the outlet pressure to the drum rises. As a result, the valve must have a large capacity with minimal pressure drop. Some plants use two valves in parallel, one designed for start-up conditions and the other for mid- to full load. The other approach is to use a single valve with a characterized disk stack designed to accommodate varying flow conditions.

Whichever approach is taken, the feedwater regulator valve must have an actuator that can smoothly and accurately adjust feedwater flow. The valve doesn't need to be extremely fast, because the digital control system will tune the loop for optimum operation. But the actuator should respond to the command without added delay and execute the command without overshooting or undershooting.

Pneumatic actuators cannot achieve the highest level of control performance because air is compressible. When the command is given to increase the air pressure and move the valve, there is a lag while the air pressure increases to the point where it is high enough to overcome the static friction of the actuator and start it moving. Pneumatic actuators also tend to overshoot the set point. This dynamic is known as hysteresis, and is a common occurrence in pneumatic control valves. "Smart" pneumatic positioners slow the actuator as it nears the set point to reduce the amount of overshoot, but the adverse affect is that they also increase the "deadtime" in the process loop and ultimately inhibit the controls engineer in optimum loop-tuning. It is common for pneumatic actuators to add seconds of deadtime into the process loop, making them more difficult to tune for high levels of process performance.

One alternative for improved control is for a plant to use hydraulic actuators. Hydraulic fluids are incompressible by nature, have immediate response and move to position in a stable and repeatable manner without overshooting and without hysteresis. The detriments of electro-hydraulic control systems (EHC's) are in that they are more expensive than pneumatic systems and require a network of components: an external gravity fed reservoir, constantly running motors/pumps, expensive filtering systems and typically handling of fire retardant oil. Because of these components, EHCs have given maintenance department's headaches for years. Although the performance of hydraulic systems is undeniably more robust and more accurate, the trade-offs associated with maintaining these systems offset their inherent benefit.

Gaining Control

To address its feedwater problems, PSEG decided to use an "electraulic" (electro-hydraulic) actuator from Rexa. The Rexa actuators are self-contained units that combine hydraulic, electronic and mechanical technologies. Rexa actuators provide performance commensurate with typical hydraulic systems (0.05 percent resolution and 70mSec deadtime), but eliminate the maintenance-intensive requirements associated with EHCs.

Electraulic actuators have two main components, a power module and a control enclosure and operate by moving hydraulic fluid from one side of a double-acting cylinder to the other.

Inside the power module are a motor, gear pump, flow match valve, 60cc thermal expansion/make-up oil reservoir, heater and thermostat. Upon receipt of a control signal, the pump delivers oil at a nominal 2,000 psi to one side or the other of a hydraulic cylinder, causing motion in the desired direction. The hydraulic cylinders come in either linear or a rack-and-pinion rotary design. A position sensor is mounted within or adjacent to the cylinders and provides position feedback to the control electronics.

The control sub-assembly contains the central processing unit (CPU), power supply and motor drivers. The CPU typically contains a microprocessor, an analog-to-digital converter, a position transmitter, limit switches and warning and alarm systems. The power supply takes the incoming AC power and coverts it to the voltages required by the control components. The motor driver receives commands from the CPU and sends control signals to the motor. Outside of the enclosure (or inside when conditions require) is a two-line display giving actuator status and a five-button keypad to set up and calibrate the actuator.

When used to control a feedwater regulator valve, the CPU receives a control signal from the DCS and converts it to a target position for the actuator. It then compares current position of the actuator as reported by the feedback assembly with the desired new position. If the difference is outside the preprogrammed range the CPU will send a signal to start the motor, which then drives the reversible hydraulic pump to pressurize one side of the cylinder or the other, moving the piston in the desired direction. Once it reaches the new position, the pump shuts down and check valves close. This locks the hydraulic fluid in the cylinder and maintains the actuator position, without having to keep the motor running, until a new signal is received from the DCS.

Nice and Flat

PSEG's Mercer plant has two 350 MW GE steam turbines, each with dual boilers. Unit 1 went on line in 1960 and Unit 2 the following year. Each of the four boilers had 10-inch Bailey pneumatic piston

There were also maintenance problems. The actuators needed to be rebuilt annually and there were ongoing problems of dirt in the pneumatics and pistons leaking. The first two Rexa actuators were installed in a 2002 outage. The Bailey valves were replaced with CCI valves as part of the upgrade.

"We just had to take the old stuff out, pop this on top and we were ready to go," Maute said.

The following year PSEG replaced the actuators on the other unit and they have been working smoothly ever since. Maintenance problems have disappeared and the plant no longer needs to wait for drum levels to stabilize before providing power.

"The drum levels are nice and flat, they don't move at all," said Maute. "Now if the DCS gives us a response, the valve actually moves where it is supposed to." pe