A High-Tech Boost for Performance

by James Piper

Controls advances can deliver benefits for energy efficiency, emissions, maintenance and safety

A fundamental and far-reaching change is taking place in boilers. While boiler construction is not all that much different than that of 10-15 years ago, today's boilers offer significant improvements in safety, performance and efficiency. The advance that makes these improvements possible is the changeover to microprocessor-based controls.

The microprocessor is rapidly replacing manual, pneumatic and electrical boiler control systems. Having already demonstrated its effectiveness in building HVAC temperature-control systems, microprocessor-based controls have become tools of manufacturers looking to improve boiler performance.

Faced with rising fuel costs and tighter environmental regulations, manufacturers soon realized that existing control systems simply could not provide the level of performance required. Microprocessor-based controls could improve boiler performance, reduce fuel requirements and decrease emissions. They also could provide operators with information they needed to monitor operations, diagnose developing problems and reduce downtime.

Understanding controls

Boiler control systems perform three basic functions combustion control, water level control and flame safeguarding. Installations with multiple boilers require a fourth control function - sequencing.

Proper operation of combustion controls is essential to minimize fuel costs and boiler emissions. Combustion controls can be as simple as on-off cycling of the burner, or they can be fully modulating. On-off cycling generally is restricted to smaller boiler systems where it might not be so important for the burner to match the boiler's load. The use of modulating-combustion controls is a more efficient means of achieving this goal.

The basic modulating control varies both the flow of fuel and the air damper, based on the desired boiler output temperature or pressure. A more complex modulated control known as oxygen-trim control varies the fuel flow and air damper positioning to maintain the most efficient air-to-fuel ratio.

Water-level controls are designed to maintain a specific level of water in the boiler under all operating loads. Under normal operation, these water levels vary due to load swings and water or steam losses in the system. Keeping the water level at the setpoint improves operating safety, increases operating efficiency and allows the boiler to respond more effectively to changing loads.

The flame safeguard control is the most important safety control in the boiler. It monitors the boiler's flame, water level, fuel and air interlock, and operating pressure and temperature. It also controls the purge, startup and shutdown sequences.

Of these, controlling the purge sequence is most important for operating efficiency. Each time a boiler is started, it must be purged with air to ensure that no residual fuel is present. Purging cools the boiler, resulting in significant losses, particularly if the boiler is cycled frequently.

For multiple-boiler installations, a fourth control is added that controls boiler modulation and sequencing according to the load. These controllers bring on as many boilers as are required, modulating the firing rate of each boiler to match the load.

Enter the microprocessor

Today's boiler control systems are vastly different from earlier-generation systems. One apparent difference is the way in which systems are operated.

In conventional control systems, operators monitor and adjust boiler parameters from individual control panels, typically mounted on each boiler. Large boiler plants might have remotely mounted monitoring panels, but in most installations, operators must make any adjustments to the boiler's operation at each individual boiler.

Microprocessor-based controls allow true centralized operation of multiple boilers. Operators at central consoles can monitor and adjust the operation of any boiler in the plant as required. Boilers can even be monitored remotely, which allows a single operator to oversee multiple boilers in multiple buildings from one location.

The result is more efficient and effective operation of boiler systems. Changes in operating conditions can be handled quickly, without having to dispatch an operator.

The latest generation of boiler control software also is making the systems even easier to learn and use. Many software applications are PC-based and use Windows based software. Features such as interactive displays, graphical user interfaces, and standardized commands and data formats increase system capabilities and give operators a wealth of operating data.

Higher operating efficiency

Pneumatic and electric control systems are notoriously slow in responding to system changes, and manual controls are even worse. When a change in load occurs, boilers controlled by these systems tend to overshoot or undershoot the desired settings. Slow system response, overshoot and undershoot all result in lower operating efficiency. One significant advantage that microprocessor-based controls have over other control systems is accuracy.

Another efficiency problem associated with boiler operation is offset, which occurs when a boiler operates close to but not at a desired setting. Offset results from several factors, including inaccuracy in sensors and controls, wear in control system mechanical linkages, a lack of self-correcting feedback to the control system from the boiler, and built-in tolerances in control-system components. Offset also reduces boiler efficiency.

Microprocessor-based controls eliminate most of these sources of efficiency loss. The constant monitoring of a much wider range of operating parameters - including steam pressure, gas pressure, supply-water temperature, flue-gas-discharge temperature, and flue-gas oxygen and carbon-dioxide concentrations -provides feedback to the control system, allowing it to adjust to even minor changes in loads. Monitoring flue-gas oxygen and carbon-dioxide levels keeps excess air levels to a minimum, resulting in improved operating efficiency without increased emissions.

Besides more closely controlling boiler operation, microprocessor-based controls monitor additional factors, such as outdoor-air temperature. In systems where the boiler is used primarily to supply steam for building beating, monitoring outdoor-air temperature allows the control system to reset the supply pressure according to weather conditions, resulting in improved operating efficiency.

Greater operating safety

One problem with conventional boiler control systems has been the speed with which they detect problems and either take corrective action or report it to operators. In many cases, operators must intervene and correct the problem or eliminate safety hazards.

Microprocessor-based systems eliminate the delay between detection and correction, and they can be programmed to take specific actions in the event of hazardous conditions, eliminating the need for operator intervention. They can even be programmed to notify remote personnel the moment problems develop.

Even tasks such as starting a boiler can be made safer. Operators typically estimate system-purge requirements. By monitoring conditions within the boiler, the control system can determine the purge requirements for the boiler and automatically implement them along with the automated startup sequence.

Reduced emissions

One motivating factor behind the development of microprocessor-based controls is the push to limit boiler emissions. For example, the Clean Air Act set lower limits on emissions, particularly carbon monoxide and nitrous oxide (NOx). To meet these new standards, manufacturers updated boiler designs to include the use of flue gas recirculators and low-NOx cones on burners.

But microprocessor-control systems have been one of the most effective means of limiting emissions. By constantly monitoring flue gases, the systems can quickly detect and correct operations to bring the boiler in compliance with the stricter standards.

Improved maintenance

Early detection is an important factor in reducing maintenance costs and increasing system life in any building mechanical system because it allows operators to take corrective action while the problem is relatively small. Early detection of problems also allows operators to schedule maintenance shutdowns, rather than having a failure occur and force an unscheduled shutdown. Microprocessor-based controls give operators the ability to more closely and accurately monitor boiler operation, making it easier for them to detect problems as they develop.

Several factors contribute to a control system that is maintenance friendly. Conventional control systems typically monitor no more than 10 different operating parameters. Microprocessor-based systems monitor many more, with most monitoring at least 80 for each boiler. By monitoring a much larger number of operating parameters, it is easier for the system to detect conditions that might cause or result from boiler maintenance problems.

Besides monitoring more elements of a boiler's operation, the system also records and stores data that system operators can access. They can analyze trends in boiler operation by reviewing stored data, and they can make comparisons in operating performance and efficiency, giving a good overall indication of the boiler's health.

And when a problem does occur, operators can review data to identify events that led up to or contributed to the problem. As a result, they can make changes in operating procedures to prevent problems from recurring.

To date, most boiler control systems have been proprietary and standalone. But the development of standard protocols for building automation systems offers the potential for standardization of boiler controls.

If standards are adopted, boiler control systems will be able to interface directly with other building automation systems, allowing even more comprehensive and complex controls to be developed to improve operation and increase operating efficiency.

Another promising area is the use of individual microprocessors at various locations in a system, instead of just at a central computer. And managers can look for increased system capabilities as more intelligence is added to system devices, such as sensors, transmitters and actuators.

Over the past 10 years, microprocessors have revolutionized the building HVAC industry, resulting in increased reliability and reduced energy requirements. Today, the revolution has spilled over to the building boiler controls industry, with the same promise of improved performance.

Above article appeared previously in the March 2001 issue of Maintenance Solutions and is written by James Piper, P.E., a consultant based in Bowie, Md., with more than 25 years of facilities management experience.