Boilers Helping to Usher in New Age of Hydronics

Hydronic equipment provides efficiency, system flexibility

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Is the United States on the verge of a new age of hydronics? Smarter and more energy-efficient hydronic technology similar to what has evolved in Europe over the last several decades is getting a new look from system designers seeking to design larger buildings to new environmentally conscious standards. With technology, fewer materials are required for HVAC-system performance, and less energy is consumed during operation.

Proof that a new hydronics age has arrived includes:

• Hydronically driven chilled-beam cooling systems have entered the U.S. marketplace. Their low-profile systems wick away British thermal units quickly.

• Radiant heating and cooling systems have moved beyond their probationary period, offering efficiency and quiet/reliable operation.

• Modern fan coils are more capable and durable than their ancestors. They can be connected to boilers, water-source heat pumps, geothermal systems, or ultrahigh-efficiency modular chillers to deliver comfort year-round.

This article will focus on modulating-condensing boilers, which have achieved near-perfect efficiency levels. What was inconceivable just a decade ago is now a reality.

The Costs of Energy

The silver lining to the energy crisis is that consumers have a newfound awareness of and appreciation for the financial and environmental costs of energy. Also, the market is learning that the rewards for investing in new technology can be significant.

"There's no question that the 'green movement' is here to stay," Chuck O'Donnell, product marketing manager for Rochester, N.H.-based Laars Heating Systems Co., a subsidiary of Bradford White Corp., said. "It's been a powerful market driver, slowed only by the downcast economy. But the Europeans and some Asian countries have shown us the power and positive influence of a 'green infrastructure,' ... and our government's incentives to go green have at least given new energy to the effort, despite economic woes."

The newest generation of hydronic equipment—such as condensing technology that extracts heat from condensate—recovers heat that used to go "up the chimney" for hydronic use, pushing combustion efficiency into the 95- to 99-percent range. Additionally, hydronic equipment can be fitted with new and sophisticated controls and inte-

PHOTO COURTESY OF LAARS HEATING SYSTEMS CO.

Commissioning of modulating-condensing boilers in a Canadian hotel.

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grated with a building-automation system (BAS).

With this kind of efficient performance, building owners are coming to attention. When a design engineer can calculate a three- to four-year payback for new equipment, there is incentive to install new technology.

System Efficiency

How effectively a boiler relates to a system is determined by how fast it can deliver heat, which depends on system needs and the boiler's ability to adjust to demand changes (commonly referred to as "sizing to load"). Total system performance is enhanced when equipment works at peak performance—when fuel is consumed at peak combustion efficiency—at all levels of heat demand.

Additionally, more-sophisticated controls can sample modifications over time and "learn" a system's responses to changes in conditions, such as heating load, outdoor-air temperature, and boiler firing stages.

"And, of course, there's modulation or staged firing vs. on/off," O'Donnell said. "Modulating and staged-fired boilers reduce fuel consumption by sizing to the load so that the amount of heat produced by the system precisely matches the need."

Maintenance and Smaller Systems

O'Donnell explained that recent boiler-technology developments include higher efficiencies for combustion, as well as electrical (amp) draw from pumps, blowers, and valves. However, advanced high-efficiency heat-exchanger technology can require more maintenance scheduling.

"In order to keep condensing heat exchangers running optimally, they must be inspected and cleaned yearly," O'Donnell said. "Otherwise, there's likely to be a decrease in output efficiency and a reduction in fuel-usage savings."

The market also is moving toward smaller boilers as heat-exchanger-design technology improves.

"Space is a valuable commodity in commercial settings, and the smaller the mechanical room, the better," O'Donnell said. "This extends to apartment and condominium construction, where small wall-hung combination boiler/water-heater units are often desired, especially where building owners want tenants or unit owners to have separately metered and funded utility services."

Smarter Controls

The boiler market also is moving toward more sophisticated control systems, O'Donnell said.

"Regardless of the fuel used—with electric boilers as the only exception—a flame is the source of heat in a boiler's heat exchanger," O'Donnell said. "Our task of moving that heat from the combustion chamber is much the same today as it was decades ago, albeit with far greater efficiency. Where we're seeing the greatest influence of new technology is in a boiler's control systems."

Because of advanced electronics, more user-friendly displays and "language," and modular component design, boilers will become easier to troubleshoot and maintain. Advanced boiler electronics likely will become self-diag-

PHOTO COURTESY OF LAARS HEATING SYSTEMS CO.

Installation of modulating-condensing boilers in a midwestern manufacturing facility.

BOILER-RATING SCALE

A quick checklist can summarize optimal boiler-system design and function. How well does your boiler system—hydronic or volume water heating—rate?

- System efficiency (including controls, circulation, and heat distribution).
- Control logic.
- Modulation or stage-firing.
- Thermal efficiency.
- Outdoor-air-temperature reset.
- Nitrogen-oxide emissions.
- Sealed combustion vs. atmospheric ventilation (Category I, II, III, IV).
- Acceptance of commands from a building-automation system (BAS).
- Sending information back to a BAS.
- Footprint size. Do heating systems need to be racked to increase the density of British thermal units per square foot?
- Filtered combustion air.
- Wiring and water and gas connections.

nostic, indicating not only what may be wrong in a boiler system, but what steps should be taken to fix the problem.

Information Exchange

"Information exchange" refers to a boiler's ability to receive external information, such as outdoor-air temperature, BAS instructions, and system zone information and send internal data, such as inlet and outlet water temperature, operating cycles, fuel consumed, and pump operation, back to a BAS. These functions play an important role in the exchange of information, helping to:

• Accept communication signals (BACnet, LON, Metasys, Echelon) from a BAS.

• Report internal information to a BAS.

• Collect information concerning operation and efficiency, such as run time, percent load, domestic-tank temperature, and system-loop temperature.

User interfaces also assist with information exchange. How well and how easily a user can change operational settings is important. Users should be able to see and discern what a boiler is doing. A boiler's command system needs to be easy to understand, intuitive, and user-friendly. The functionality, usability, and accessibility of keypads and displays should be considered. For example, will an installing or service contractor or plant-maintenance supervisor looking to determine a unit's temperature find himself or herself standing in front of the unit at eye level or on his or her knees with a flashlight?

Efficiency

Efficiency is just one of the advantages of a condensing-boiler system. Application type can play an even more important role in choosing to install a condensing-boiler system.

"Tough resistance to thermal shock and the ability to accept low return-water temperatures puts (condensing-boiler systems) in a category of their own and opens up many new possibilities for high-volume, cold-start systems," Kolyn Marshall, engineer and marketing manager for Springfield, Mo.-based Watts Radiant, said. "One example is a commercial snow-melt system. A condensing boiler takes very low inlet temperatures in stride. In fact, the lower the temperature of incoming water—or a water/glycol mix as is usually the case—the higher the combustion efficiency of the boiler."

When boilers operate with low return-water temperatures and firing rates, combustion efficiency and the ratio of heat-transfer surface to fuel consumed combine to deliver maximum efficiency. Additionally, when multiple boilers are installed, each one handles only a portion of the heating load, driving system efficiency even higher.

To maximize efficiency, many system designers agree that modern boiler systems need to be able to:

• Predict building-load requirements with matched firing rates.

• Optimize outputs with proportional-integral-derivative (PID) controls using outdoor, indoor, and system water temperatures.

• Optimize fuel consumption and heat distribution with modulating combustion systems and variable-speed pumps.

• Communicate easily with various types of BAS via different protocols.

• Transmit status reports to various locations or computers, handheld devices, phones, and personal digital assistants via the Internet. Ideally, a checklist that identifies diagnostic issues would accompany a status report.

PHOTO COURTESY OF LAARS HEATING SYSTEMS CO.

Total boiler-system performance is enhanced when fuel is consumed at peak combustion efficiency at all levels of heat demand.

Putting Green in Context

Going green with large mechanical systems can be expensive, but making improvements to the environment and operating costs can be done in measured steps.

For instance, a highly efficient condensing boiler can handle 80 percent of the annual heating load when installed in the lead position. A second midlevel-efficiency boiler can handle the additional 20 percent of needed load at a lower cost during the coldest days of the year, when the lead boiler cannot carry the entire load. By taking this approach, gas use is reduced, keeping project costs to a minimum.

Of course, what exists beyond the boiler jacket and near boiler piping impacts overall system performance. Circulation, control solutions, and heat distribution should be considered.

New market pressures will demand combined systems, connecting and integrating renewable sources with high-efficiency boilers: geothermal, solar thermal, photovoltaic, or biofuel/biogas.

"For instance, a geothermal or water-sourced heat pump may preheat water coming into a volume-water application, reducing the load," John Bailey, vice president of Oklahoma City-based ClimateMaster Inc., said. "Or a boiler could provide backup heat for a geothermal or water-sourced heat-pump system that's sized to meet the heat load a majority of the time."

Variable-Speed Pumping

One of the most important facets of optimizing circulation for hydronic systems is matching a pump's performance or flow characteristics to the specific job it needs to perform.

According to Greg Cunniff, PE, application engineering manager for Cranston, R.I.-based Taco Inc., a single-speed pump has one performance curve—a measurement of head and flow—and operates at that level only for a particular condition. For the right application, fixed- or multispeed pumps are the industry's workhorses.

Variable-speed pumps, including close-coupled, vertical inline variable-frequency drives (VFDs), and larger base-mounted, end-suction pump lines, offer a broader range of performance for jobs that demand varying fluid pressures and volumes.

PHOTO COURTESY OF LAARS HEATING SYSTEMS CO.

Modulating and staged-fired boilers reduce fuel consumption by sizing to load.

Whether added to fixed-speed pumps to enhance performance and lifespan or integrated into a pump by design, VFDs systematically monitor the need for and alter head and flow to meet a system's specific needs.

When matched with optimal output, VFDs deliver reliable performance and increase productivity while reducing energy consumption. They are designed to enhance reaction times and offer complete scalability to match application requirements for speed, size, and protection. Also important are simplified installation, configuration, and maintenance; advanced diagnostics and voltage ride-through capability; and seismic qualification.

Single-Pipe Systems

Engineers, system designers, and building owners are beginning to see the advantages of hydronics, including long-term performance, efficiency, and system flexibility.

"A recent development in commercial hydronic-system design is illustrative of (the advantages of hydronics)," Robert Jauch, vice president of sales for Oklahoma City-based IEC, a manufacturer of hydronic heating and cooling fan-coil units for commercial applications, said. "It's the single-pipe-series decoupled system which provides exceptional comfort and efficiency."

Able to utilize fewer materials and nearly self-balancing, a single-pipe primary loop typically is routed past a block of fan coils. The loops are configured horizontally or vertically as required by a building's design. System enhancements can permit individual-zone function, revealing commercial and institutional opportunities.

Simplicity is the hallmark of a single-pipe system. A conventional two-pipe system requires a supply and return pipe in the primary circuit, which requires more materials and takes up more space. This can be a challenge if space is at a

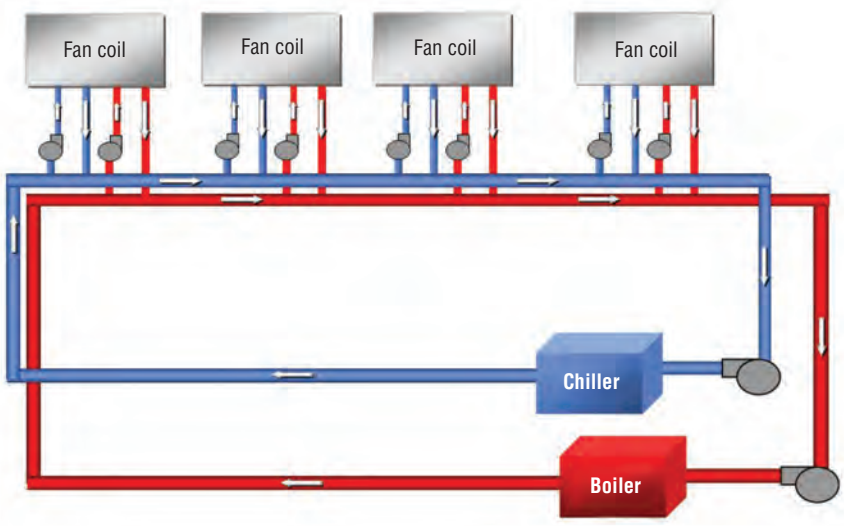

FIGURE 1. A series circuit with single-pipe primary loops.

premium. However, a single-pipe system can save space and labor because only one pipe has to be installed.

A system with a single-pipe primary main can use terminal units configured with decoupled secondary circuits. Wet-rotor circulators, tied to a thermostat to govern the operation of individual fan-coil units, can direct water through the local-zone secondary system.

When circulators are used, zone control valves are not necessary. Because the flow in secondary circuits is independent of the flow in primary circuits, there also is no need to use water balancing valves at each fan-coil unit. By eliminating both types of valves and having only a single-pipe primary circuit, the system is simple in its design and uses less material than a standard two-pipe system—an average of 40-percent-less pipe and fittings, no control valves, and almost no balancing valves.

According to Jauch, a single-pipe system also has lower head loss and reduced pump horsepower requirements than a conventional two-pipe system because control and balancing valves are eliminated. Also, block-load operational-diversity system design helps reduce a single-pipe system's energy consumption.

"These savings, plus reduced maintenance of the circulators, can significantly reduce the building life-cycle cost," Jauch said.

Figure 1 illustrates a series circuit with compound pumping and separate single-pipe primary loops for cooling and heating.

Chilled and hot water flow continuously through primary distribution loops with pressure provided by central primary-system pumps. Multiple cooling and heating primary loops are configured in parallel to feed separate buildings, floors, wings, or zones. Local unit-mounted circulators cycle on and off, governed by a local room thermostat (traditional zone control valves are not needed).

While operating during periods of demand, pumps borrow a portion of water from the primary loop, pushing it through a fan-coil unit. The tempered water then is returned to a downstream connection on the same primary loop. The used water simply blends with the primary water delivered to the next fan-coil unit downstream.

Chillers and boilers typically operate from secondary pumps, decoupled from the network of primary loops. Primary system pumps are selected for constant water flow with minimal pump head.

A single-pipe configuration is useful in commercial structures, such as libraries, dormitories, and high-rise condominiums or hotels in which water-velocity noise must remain below a specific threshold, typically 6 fps.

PHOTO COURTESY OF LAARS HEATING SYSTEMS CO.

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Conclusion

High-efficiency hydronics and proper system and component integration have a bright future. Any project can be "greened" in some way, and high-efficiency hydronic systems can help the United States reduce its energy consumption.

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