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5.2.1 Boilers

Most medium-to-large facilities use boilers to generate hot water or steam for space heating, domestic water heating, food preparation, and industrial processes. For boilers to run at peak efficiency, operators must attend to boiler staging, water chemistry, pumping and boiler controls, boiler and pipe insulation, fuel-air mixtures, burn-to-load ratio, and stack temperatures.

Opportunities

Every effort should be made to upgrade boiler systems to peak efficiency in order to reduce operating costs and environmental impacts. When replacing old equipment or installing new equipment:

- Consider the advantages of multiple boiler systems, which are more efficient than single boilers, especially under part-load conditions.
- Consider solar-assisted systems and biomass-fired boilers as alternatives to conventional boiler systems.
- Consider opportunities for cogeneration (combined heat and power), including the use of fuel cells and microturbines as the heat source.

Technical Information

Note recent trends in boiler systems, which include installing multiple small boiler units, decentralizing systems, and installing direct digital control (DDC) systems, including temperature reset strategies. Because these systems capture the latent heat of vaporization from combustion water vapor, flue-gas temperatures are low enough to vent the exhaust through polyvinyl chloride (PVC) pipes; PVC resists the corrosive action of flue-gas condensate.

Replace inefficient boilers. In newer units, more fuel energy goes into creating heat, so both stack temperatures and excess oxygen are lower. Estimate efficiencies of existing units by measuring excess air, flue and boiler room temperatures, and percent of flue-gas oxygen and carbon dioxide. Some utilities will provide this service free of charge. Boilers are available that have efficiencies greater than 90%.

Decentralize systems. Several smaller units strategically located around a large facility reduce distribution losses and offer flexibility in meeting the demands of differing schedules, as well as steam pressure and heating requirements. Estimate standby losses by monitoring fuel consumption during no-load periods.

Downsize. Strive to lower overall heating demands through prudent application of energy conservation measures, such as increased building insulation and improved glazings. Smaller boilers may be staged to meet loads less expensively than large central plants. Many new units are designed to ease retrofit by fitting through standard doorways.

Modernize boiler controls. Direct digital controls consist of computers, sensors, and software that provide the real-time data needed to maximize boiler system efficiency. They allow logic-intense control functions to be carried out, such as temperature reset, optimizing fuel/air mixture based on continuous flue-gas sampling, managing combustion, controlling feedwater and drum levels, and controlling steam header pressure.

Install an economizer. Install a heat exchanger in the flue to preheat the boiler feedwater. Efficiency increases about 1% for every 10°F (5.5°C) increase in feedwater temperature. If you are considering an economizer, ensure (1) that the stack temperature remains higher than the acid dew point in order to prevent flue damage, and (2) that excess flue temperature is due to insufficient heat transfer surfaces in the boiler rather than scaling or other maintenance problems.

Install an oxygen trim system. To optimize the fuel/air ratio, these systems monitor excess oxygen in the flue gas and modulate air intake to the burners accordingly.

Reduce excess air to boiler combustion. The common practice of using 50–100% excess air decreases efficiency by 5%. Work with the manufacturer to determine the appropriate fuel/air mixture.

Install air preheaters that deliver warm air to the boiler air inlets through ducts. The source of warm air can be the boiler room ceiling, solar panels, or solar-preheat walls. Managers should check with boiler manufacturers to ensure that alterations will not adversely alter the performance, void the warranty, or create a hazardous situation.

Source: HydroTherm

The Multi-Pulse boiler from Hydrotherm offers an annual fuel utilization efficiency (AFUE) of over 90%. Multiple units can be ganged for higher output requirements.

Install automatic flue dampers to reduce the amount of boiler heat that is stripped away by natural convection in the flue after the boiler cycles off.

Retrofit gas pilots with electronic ignition systems, which are readily available.

Add automatic blowdown controls. Uncontrolled, continuous blowdown is very wasteful. A 10% blowdown on a 200 psia steam system results in a 3% efficiency loss. Add automatic blowdown controls that sense and respond to boiler water conductivity and pH.

Add a waste heat recovery system to blowdowns. Capturing blowdown in recovery tanks and using heat exchangers to preheat boiler feedwater can improve system efficiency by about 1%.

Consider retrofitting boiler fire tubes with turbulators for greater heat exchange, after checking with your boiler manufacturer. Turbulators are baffles placed in boiler tubes to increase turbulence, thereby extracting more heat from flue gases.

Insulate boiler and boiler piping. Reduce heat loss though boiler walls and piping by repairing or adding insulation. The addition of 1 inch (2.5 cm) of insulation can reduce heat loss by 80–90%.

OPERATION AND MAINTENANCE

Proper operation and maintenance is the key to efficient boiler operation. Any large boiler plant should maintain logs on boiler conditions as a diagnostic tool. When performance declines, corrective action should be taken.

Reduce soot and scale. Deposits act as insulation on heat exchangers and allow heat to escape up the flue. If the stack temperature rises over time under the same load and fuel/air mixture, and deposits are discovered, adjust and improve water chemistry and fuel/air mixture accordingly. Periodically running the system lean can remove soot.

Detect and repair steam leaks. Though they are not directly boiler-related, leaks in underground distribution pipes can go undetected for years. Monitor blowdown and feedwater to help detect these leaks. Repair them promptly.

> On systems operating with negative pressure, air may enter the system after combustion and give false indications of excess air measured with flue-gas oxygen.

References

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