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UTILITIES MANAGER

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How to...

Bring Life Back To Your Ailing Boilers

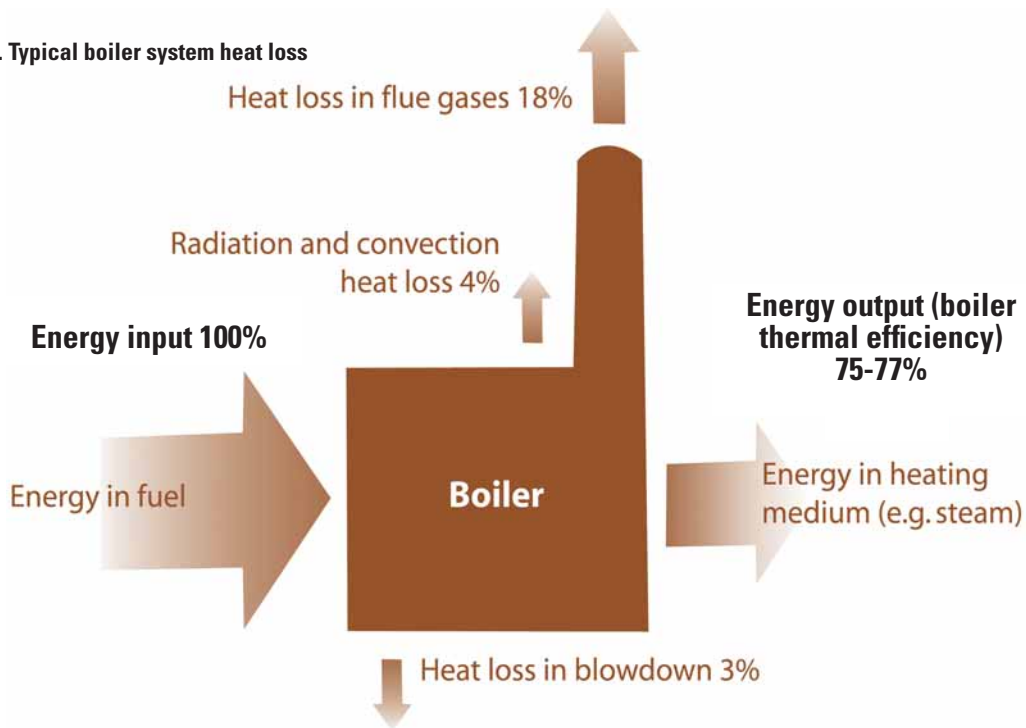
*What can you do when
you are expected
to generate steam
efficiently, but you have
to do it with aging,
inefficient equipment?
Think retrofits.*

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As a utilities manager, you know how critical steam is to an operation's power, process heat and indoor climate-control needs. With almost one-third of your energy bill being run up by the boiler room, system inefficiency—a *leading factor in increased boiler operating costs*—simply can't be ignored.

Fig. 1. Typical boiler system heat loss



According to the Department of Energy, almost 80% of boilers in the United States today are nearly 30 years old or older. This means the chances are pretty good that you're working with a unit that is not operating at optimal efficiency—*possibly only in the 75% to 80% range*. Making your job even harder, tight budgets are putting increased scrutiny on capital spending, often leading to the postponement of necessary infrastructure upgrades such as new boilers. You're left with aging, inefficient equipment.

Don't give up. There is another way to efficient operation. You can retrofit your old boiler to bring its performance nearly up to par with today's new systems. This article discusses the major retrofit options available to minimize energy loss and maximize fuel dollars.

Identifying the real culprit

To improve boiler efficiency, you first must identify your efficiency problems. The main cause of energy inefficiency is system heat loss. The average level of efficiency for industrial boilers is only 75% to 77%, with roughly one-quarter of fuel producing heat and energy that is never harnessed. Examples of heat loss are shown in Fig. 1.

Taking control

The first place to look for improvements is in your control system. New developments in boiler controls create opportunities for substantial efficiency gains.

Boilers must operate with an excess supply of

oxygen in the combustion gases to ensure complete combustion of the fuel, thereby yielding maximum heat energy. Too much oxygen cools the flame, and too little leads to incomplete combustion. Consequently, control of the air and fuel levels is paramount to optimal efficiency. The following control options are available for retrofitting an existing system to produce measurable efficiency increases and fuel-cost decreases.

With almost one-third of your energy bill being run up by the boiler room, system inefficiency simply can't be ignored.

Parallel positioning...

Many boiler burners are controlled by a single modulating motor with jackshafts to the fuel valve and air damper (commonly referred to as "jackshaft control"). This arrangement, set during startup, fixes the air-to-fuel ratio over the firing range. Unfortunately, environmental changes such as temperature, pressure and relative humidity alter the fixed air-to-fuel ratio, making combustion inefficient. To account for these conditions, boilers with jackshaft systems are typically set up with 4% to 7%

oxygen in the stack. This oxygen level reduces boiler efficiency and, over time, linkages wear—*making repeatability impossible*.

To solve this problem, incorporate parallel positioning into your control system. It's a process using dedicated actuators for the fuel and air valves. Air and fuel position curves are programmed into the PLC for each actuator, and repeatability is excellent. Boilers that incorporate parallel positioning need only 2% to 5% excess oxygen in the stack to ensure complete combustion.

As a general rule, boiler efficiency increases by 1% for each 2% reduction in excess oxygen. Using this

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rule, a 600 HP boiler with parallel positioning and 2.5% excess oxygen will be approximately 2% more efficient than a similar boiler operating at 6.5% excess oxygen. That equates to a savings of \$10,700 per year (based on operation at 50% average load for 12 hours per day, 365 days per year and a fuel cost of \$10/MM BTU).

O₂ trim...

Another way to ensure peak efficiency is to use an oxygen sensor/transmitter in the exhaust gas. The sensor/transmitter continuously senses oxygen content and provides a signal to the controller, which "trims" the air damper and/or gas valve, maintaining a consistent oxygen concentration. This minimizes excess air while optimizing the air-to-fuel ratio.

O₂ trim systems typically increase efficiency by 1% to 2%. Using the same scenario as above, incorporating an O₂ trim system can save \$5,000 – \$10,000 annually.

Variable speed drives...

Variable speed drives (VSDs) allow a motor to operate only at its required speed, rather than a constant 3,600 RPM as the drive would typically run. This speed variance results in the elimination of unnecessary energy consumption. A VSD can be used on any motor, but is most common on pumps and combustion air motors above 5 HP. These

drives also produce quieter operation compared to a standard motor, and reduce maintenance costs by decreasing the stress on the impeller and bearings.

The energy saved by running at variable frequencies translates easily to dollars. For example, a 50 HP motor operating at a slower speed and utilizing only 40 HP, 12 hours per day, 365 days per year, with a load factor of one and motor efficiency of 86%, will save \$3,360 per year (based on \$0.10/kWh).

Another way to please budget scrutinizers while improving energy efficiency is to incorporate heat recovery retrofits into your boiler system. The following three "post-combustion" retrofit devices are designed to recover heat loss.

Economizers...

Economizers transfer energy from the boiler exhaust gas to the boiler feed water in the form of "sensible heat." Sensible heat is created by the transfer of the heat energy of one body, in this case exhaust gas, to another, cooler body—the *boiler feed water*. This, in turn, reduces the boiler exhaust temperature while preheating the boiler feed water, increasing overall efficiency.

Economizers typically increase boiler efficiency by 2.5% to 4%, depending on the type of heat transfer surfaces and the allowable pressure drop. As a general rule, for every 40 F degree reduction in boiler gas temperature, 1% efficiency is gained.

Based on our referenced 600 HP boiler example, adding an economizer to your boiler system would result in a savings of \$13,000 – \$21,000 per year in fuel costs.

Air preheaters...

Air preheaters transfer sensible heat from the boiler exhaust gas to the combustion air required by the burner. This reduces the boiler exhaust temperature while preheating the combustion air, once again increasing overall system efficiency.

Most heater designs use plate heat exchangers to maximize surface area. Factors to consider when choosing the right air preheater include pressure drop and materials. Pressure drops will cause a reduction in boiler output unless compensated for by a larger fan motor.

Materials of construction are also critical, especially for applications where condensation and/or oil firing may occur. That's why many preheaters are built of stainless steel or incorporate a bypass to avoid premature failures.

Combustion air, required by all burners, requires energy to heat it up to combustion temperatures. Preheated air requires less energy, so overall boiler efficiency is increased. For each 40 F degree drop in

Cleaver-Brooks Hawk ICS



The Cleaver-Brooks Hawk ICS advanced control system includes the ability to integrate all of the energy-efficient options discussed in the accompanying article: parallel positioning, O₂ trim and a variable speed drive.

In addition to these critical energy-saving features, the product incorporates other elements essential to safe, reliable, efficient and emissions-reducing boiler system operation. The Hawk provides up-to-date trending data, advanced alarms, complete integration with building management systems, boiler monitoring via the Internet, and visual depictions of data and results. These advancements in control technology make it easier for plant personnel of any level to positively affect the bottom line.

boiler exhaust temperature, the overall boiler system efficiency increases by about 1%.

Again using our 600 HP boiler example, the addition of an air preheater for a 1.5% efficiency gain would result in a savings of \$8,000 per year in fuel costs.

Transport membranes...

Although transport membranes aren't commercially available today, these recovery tools are in the final stages of development and will be coming on the market within the next year. Thus, they're an important option to understand for the future.

Transport membranes recover both latent and sensible heat from the boiler exhaust and dehumidify it at the same time. At a recent beta site, the combining of this type of membrane with an economizer and controls detailed in this article, created system efficiencies greater than 94%, far surpassing the average 75% to 77% discussed earlier.

Using our 600 HP boiler example one last time, the addition of a transport membrane condenser, in combination with an economizer and updated controls, can create 10% efficiency gains, or save \$53,000 annually in fuel costs.

Getting it done

The retrofits discussed in this article represent most of the major boiler energy savings available to utility managers today. Others include insulating steam piping and blow-down heat recovery. To learn more, it's a good idea to consult your retrofitting options with a boiler professional. **UM**

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