Understanding Boiler Fuel Efficiency

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Steam gets no respect. While it performs an impressive range of thermal tasks, it is widely perceived as a "support" utility, a power source subordinate to the process or thermal transfer.

But whether steam is duly appreciated or not, steam systems account for 30 percent of industry's energy consumption and represent a significant investment. In the United States each year, industry, commerce and the military spend about $46 billion to make steam.

Not surprisingly, the efficiency of many of these systems can be improved by 10 to 15 percent, according to a Department of Energy study. Focusing on 66 major steam plants, the study found that:

- 12.3 percent of fuel consumption was avoidable.
- Improvement payback averaged 1.7 years.
- Only half of the improvable systems required capital investment; the remainder required only operational or performance modifications.

Yet only one-third of the systems were subsequently improved.

Why is boiler efficiency important? Fuel expense is typically large, and a relatively small difference in efficiency will result in significant savings in ongoing operating costs.

Always Consider a Boiler's Efficiency

Considering an upgrade to a newer steam generating system? Efficiency is an important part of your purchase decision. One boiler may cost less than another, but your comparison only starts there. It's imperative that you consider fuel savings from better efficiencies. The annual fuel bill is likely to be two to three times the installed cost, and the first year's savings with the more fuel-efficient unit can easily exceed the difference in installed cost. Even more, the savings are ongoing.

When you're considering efficiency, look at boiler combustion, unique design features and the overall system. Arm yourself with an understanding of basic terminology to your evaluation. You needn't be an expert, but familiarity with commonly used terms will make your comparison easier and more accurate.

Engineer Victor Olvera (left), general manager of Nicro Bolta, and Engineer Jorge Miguel Henriquez, general manager of Clayton de Mexico, compare notes on a new steam-generating system installed in Nicro Bolta's plant in Puebla, Mexico.

Among the terms with which you should become familiar is boiler efficiency. Often used, the term "boiler efficiency" is basically meaningless unless it can be qualified. Other terms include:

- Thermal efficiency, which refers to the efficiency of the boiler's heat exchanger.
- Combustion efficiency, which is the total heat released in combustion minus heat lost in the stack gases. Combustion efficiency is widely used and easy to quantify.
- Fuel-to-steam efficiency, which is combustion efficiency minus the percent of heat lost through radiation and convection.

Fuel-to-steam efficiency is the most important measure of a boiler's efficiency, but is the most difficult to calculate in real-world situations. Think of it as the measure of energy converted to steam. Fuel to steam is based on fixed conditions such as 100 percent load and specific air and feedwater temperatures.

Certain components of combustion — fuel specification, stack temperature, excess air, ambient air and radiation/convection losses — contribute to fuel-to-steam efficiency. With fuel, for example, higher hydrogen content results in more water vapor, which uses energy as it changes phase in the combustion process, resulting in lower efficiencies. Further, under identical conditions, the use of fuel oil often results in 2.5 percent to 3 percent higher efficiency than natural gas.

Stack temperature is an indication of actual efficiency. It is an inverse relationship in that the lower the stack temperature, the higher the efficiency.

Excess air is air supplied to the burner beyond the amount required for complete combustion. Firing at low excess air levels can result in high carbon monoxide and boiler sooting. Excess air uses energy from combustion, reducing the efficiency of the boiler. Seasonal changes in temperature and barometric pressure can cause the excess air in a boiler to fluctuate 5 percent to 10 percent.

Also, ambient air temperature can have a dramatic effect on boiler efficiency. A 40°F (22°C) variation in ambient air can affect the efficiency by 1 percent or more. Radiation and convection losses, a function of the air velocity across a boiler, refer to heat that escapes through the boiler.

Design Makes a Difference

Boiler efficiency is always affected by the components of combustion, but unique design characteristics can improve operating efficiency. These include overall size, heat exchanger design, water circulation, startup time, blowdown and steam quality.

Boiler size alone is a strong determinant of overall efficiency. Smaller boilers with less surface area are inherently more efficient. The heat exchanger creates the steam, and certain designs are more efficient in

Real-Life Example:
Steam Generators Help Improve Chromium-Plating Process

There's heat. There's sufficient heat. And there's precisely controlled heat. Nicro Bolta of Puebla, Mexico, a global leader in chromium plating, needed temperature-controlled heat in large quantities in its electrolytic process.

The company, a joint venture between Nicro S.A. de C.V. and Germany's Bolta Werke GmbH, specializes in the application of chromium to plastic. It uses its process primarily in the manufacture of auto grilles for Volkswagen plants worldwide. And while its Puebla plant is known as the most modern of its type in Latin America, operating management recently decided that an improved heat source would boost production efficiency and reduce costs. The electrolytic process to coat objects with chromium requires plentiful and precisely regulated heat.

With these needs in mind, the company approached Clayton de Mexico S.A. de C.V. to request a proposal for a turnkey steam and hot water system that would meet its precise specifications. These included the provision of equipment, accessories, controls, chemicals and water treatment capability. The new system had to be installed with minimal process disruption. Additionally, comprehensive start-up and personnel training were called for.

In the boiler room of Nicro Bolta, Puebla, Mexico, the new system incorporates two, 185 BHP steam generators, a 5,000-liter tank with heat exchanger to deliver 230°F (110°C) water, and a speed-controlled pumping system that ensures proper pressure at discharge points.

Clayton de Mexico, a subsidiary of Clayton Industries, operates plants in Monterey and Guadalajara. Its solution: a system incorporating two, 185 BHP steam generators, a 5,000-liter tank with heat exchanger to deliver 230°F (110°C) water, and a speed-controlled pumping system that ensures proper pressure at discharge points. The project also includes a custom designed and installed exhaust stack for combustion gases.

Following installation of the new system, Nicro Bolta management expressed satisfaction with the system and the attentive Clayton service they continue to enjoy.

Plant Maintenance Manager Francisco Javier Maldonado said, "The Clayton generators, due to their flexible design, ensure high-precision temperature control, which is critical to this operation. They replaced conventional boilers which could not supply proper hot water control. The Clayton steam generators have helped us produce better product quality and uniformity."

transferring heat than others. Boilers with forced and/or controlled water circulation are more efficient. Boilers that can startup quickly are more efficient because they do not need to be kept on fuel-wasting warm standby, waiting to respond to increased demand.

Blowdown is the removal of boiler water in order to maintain an acceptable level of total dissolved solids (TDS). The amount of feedwater removed and replaced usually ranges from less than 1 percent to 7 percent. An essential maintenance step, blowdown nonetheless results in lost BTUs and wasted treatment chemicals. However, the recovery of the heat from blowdown can further increase efficiency.

Steam quality — a measure of the moisture present in steam — is often overlooked but can contribute greatly to efficiency. A 1 percent improvement in steam quality can produce a 1 percent increase in efficiency.

The final component in overall boiler efficiency is the steam system. Elements such as feedwater temperature, piping and traps, and the quality of water softening affect efficiency. Feedwater must be preheated prior to entering the boiler. This is normally accomplished by using a portion of the steam produced, which reduces the amount of steam available to the system.

The chromium plating performed by Nicro Bolta (see sidebar) typically is used on the front grill of Volkswagen Jetta-Bora A-5.

The use of stack economizers and reclaimed condensate to preheat feedwater will reduce the amount of steam required as well as the amount of fuel required to heat the feedwater to saturation. Piping needs to be insulated and traps maintained in working order to avoid uncontrolled steam and water losses. Finally, hard water will allow scale to form on the water side of the heat exchanger, limiting the heat transfer process. A 0.125" film of scale can equal a 3 percent loss in efficiency. **PH**

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