

Minimize Boiler Short Cycling Losses

Boiler “short cycling” occurs when an oversized boiler quickly satisfies process or space heating demands, and then shuts down until heat is again required. Process heating demands can change over time. Boilers may have been oversized for additions or expansions that never occurred. Installing energy conservation or heat recovery measures may also reduce the heat demand. As a result, a facility may have multiple boilers, each rated at several times the maximum expected load.

Boilers used for space heating loads are often oversized, with their capacity chosen to meet total building heat losses plus heating of ventilation and infiltration air under extreme or design-basis temperature conditions. No credit is taken for thermal contributions from lights, equipment, or people. Excess capacity is also added to bring a facility to required settings quickly after a night setback.

Cycling Losses

A boiler cycle consists of a firing interval, a post-purge, an idle period, a pre-purge, and a return to firing. Boiler efficiency is the useful heat provided by the boiler divided by the energy input (useful heat plus losses) over the cycle duration. This efficiency decreases when short cycling occurs or when multiple boilers are operated at low firing rates.

This decrease in efficiency occurs, in part, because fixed losses are magnified under lightly loaded conditions. For example, if the radiation loss from the boiler enclosure is 1% of the total heat input at full-load, at half-load the losses increase to 2%, while at one-quarter load the loss is 4%. In addition to radiation losses, pre- and post-purge losses occur. In the pre-purge, the fan operates to force air through the boiler to flush out any combustible gas mixture that may have accumulated. The post-purge performs a similar function. During purging, heat is removed from the boiler as the purged air is heated.

Example

A 1,500 horsepower (hp) (1 hp = 33,475 Btu/hr) boiler with a cycle efficiency of 72.7% (E^1) is replaced with a 600 hp boiler with a cycle efficiency of 78.8% (E^2). Calculate the annual cost savings.

$$\begin{aligned}\text{Fractional Fuel Savings} &= (1 - E^1/E^2) \\ &= (1 - 72.7/78.8) \times 100 \\ &= 7.7\%\end{aligned}$$

If the original boiler used 200,000 MMBtu of fuel annually, the savings from switching to the smaller boiler (given a fuel cost of \$8.00/MMBtu) are:

$$\begin{aligned}\text{Annual Savings} &= 200,000 \text{ MMBtu} \times 0.077 \times \$8.00/\text{MMBtu} \\ &= \$123,200\end{aligned}$$

Suggested Actions

- Determine the efficiency and operating cost of each of your boilers and adopt a control strategy for maximizing overall efficiency of multiple boiler operations. (See page 2.)
- Avoid short cycling by purchasing a burner with a high turndown ratio, or by adding a small boiler to your boilerhouse to provide better flexibility and high efficiency at all loads. Refer to Steam Tip Sheet #24, Upgrade Boilers with Energy-Efficient Burners. (See also page 2: Boiler Downsizing.)

Multiple Boiler Operations

The most efficient boilers should be brought on-line as loads increase, with less-efficient units taken off-line first as loads drop. Subject to emissions, operations, or firing rate limits, shift loads from a boiler where steam production is expensive to one where it is less expensive.

Use automatic controllers that determine the incremental costs (change in steam cost/change in load) for each boiler in the facility, and then shift loads accordingly. This maximizes efficiency and reduces energy costs. If possible, schedule loads to help optimize boiler system performance. Powerhouses containing multiple boilers that are simultaneously operated at low-fire conditions offer energy-saving opportunities for using proper boiler allocation strategies.

Boiler Downsizing

Fuel savings can be achieved by adding a smaller boiler sized to meet average loads at your facility, or by re-engineering the power plant to consist of multiple small boilers. Multiple small boilers offer reliability and flexibility to operators to follow load swings without over-firing and short cycling. Facilities with large seasonal variations in steam use operate small boilers when demand drops rather than operating their large boilers year-round.

Resources

U.S. Department of Energy—DOE's software, the *Steam System Assessment Tool and Steam System Scoping Tool*, can help you evaluate and identify steam system improvements. In addition, refer to *Improving Steam System Performance: A Sourcebook for Industry* for more information on steam system efficiency opportunities.

Visit the Advanced Manufacturing Office website at manufacturing.energy.gov to access these and many other industrial efficiency resources and information on training.

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