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 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.

Fractional Fuel Savings = \( (1 - \frac{E_1}{E_2}) \)

= \( (1 - 72.7/78.8) \times 100 = 7.7\% \)

If the original boiler used 200,000 MMBtu of fuel annually, the savings from switching to the smaller boiler (given a fuel cost of $3.00/MMBtu) are:

Annual Savings = 200,000 MMBtu x 0.077 x $3.00/MMBtu = $46,200

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 sidebar)
- Avoid short cycling by adding small boilers to your boiler facility to provide better flexibility and high efficiency at all loads. (See sidebar: Boiler Downsizing)
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DOE/OE-102000-1116
December 2000
Steam Tip Sheet #16