AHM Energy Tips

Consider Installing a Condensing Economizer. The key to a successful waste heat recovery project is optimizing the use of the recovered energy

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Consider Installing a Condensing Economizer

Did you know that installing a condensing economizer can improve overall boiler heat recovery and steam system efficiency by up to 10%? Practically all boiler applications can benefit from this additional heat recovery such as district heating systems, wallboard production facilities, greenhouses, food processing plants, pulp and paper mills, textile plants, and hospitals. AHM & Associates can provide site-specific engineering and analysis of the efficiency improvements possible on your steam system.

A conventional feed water economizer reduces steam boiler fuel requirements by transferring heat from the flue gas to the boiler feedwater. For natural gas-fired boilers, the lowest temperature to which flue gas can be cooled is about 250°F to prevent condensation and possible stack or stack liner corrosion.

The condensing economizer improves waste heat recovery by cooling the flue gas below its dew point, which is about 135°F for products of combustion of natural gas. The economizer reclaims both sensible heat from the flue gas and latent heat by condensing flue gas water vapor (See Table 1). All hydrocarbon fuels release significant quantities of water vapor as a combustion byproduct. The equation below shows the reactants and combustion products for the stoichiometric combustion of natural gas (methane). When one molecule of methane is burned, it produces two molecules of water vapor. When moles are converted to pound/mole, we find that every pound of methane fuel combusted produces 2.25 lbs. of water vapor, which is about 12% of the total exhaust by weight.

$$CH_4 + 2O_2 + 7.5N_2 \quad CO_2 + 2H_2O + 7.5N_2$$

Since the higher heating value of methane is 23,861 Btu per pound (Btu/lb), 41.9 lb of methane is required to provide one million Btu (MMBtu) of energy, resulting in 94.3 lbs. of high temperature water vapor. The latent heat of vaporization of water under atmospheric pressure is 970.3 Btu/lb. When one MMBtu of methane is combusted, 91,495 Btu of water vapor heat of evaporation (94.3 lbs. x 970.3 Btu/lb) is released up the boiler stack. This latent heat represents approximately 9% of the initial fuel energy content. The bulk of this latent heat can be recovered by cooling the exhaust gas below its dew point using a condensing economizer. It is possible to heat water to about 200°F with a condensing economizer.

Table 1. Boiler Efficiency of Condensing Economizers

System	Combustion Efficiency @ 4% Excess O_2 (%)	Stack Gas Temperature °F
Boiler	**78 to 83%**	**350 to 550˚**
– with Feedwater (FW) Economizer	**84 to 86%**	**250 to 300˚**
– with FW and Condensing Economizer	**92 to 95%**	**75 to 150˚**

Suggested Actions

• Determine your boiler capacity, average steam production, combustion efficiency, stack gas temperature, annual hours of operation, and annual fuel consumption.

• Identify in-plant uses for heated water, such as boiler makeup water heating, preheating, domestic hot water or process water heating requirements.

• Determine the thermal requirements that can be met through installation of a condensing economizer. Determine annual fuel energy and cost savings.

• Obtain an installed cost quotation and determine the cost effectiveness of a condensing economizer. Ensure that system changes are evaluated and modifications are included in the design (e.g., mist eliminator, additional water treatment, heat exchangers). Simple paybacks for condensing economizer projects are often less than two years

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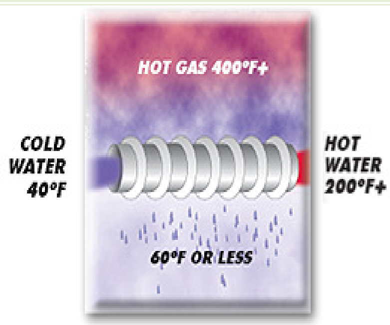
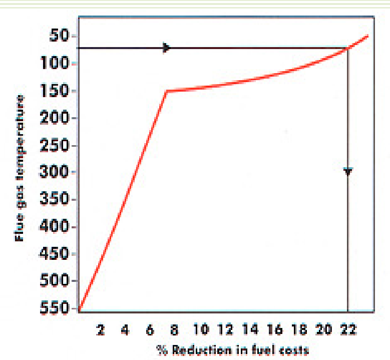
When natural gas is burned, 10% of the energy is lost because the hydrogen in the fuel combines with the oxygen in the combustion air to form water vapor. By recovering this latent heat from the exhaust gas that is cooled below its dew point, a dramatic increase in fuel savings is achieved.

Given that 12% by weight of exhaust gas (at 15% excess air) is water, significant energy savings can be achieved. Moreover, every cubic foot of gas saved eliminates one cubic foot of carbon dioxide (CO2) emitted to the atmosphere.





Energy Savings Potential - The available heat in a boiler's exhaust gases is dependent upon the hydrogen content of the fuel, the fuel firing rate, the percent of excess oxygen in the flue gases, and the stack gas temperature.

Consider a natural gas-fired boiler that produces 100,000 lbs/hr of 100-psig saturated steam. At 83% efficiency, the boiler firing rate is about 116 MMBtu/hr. At its full firing rate, the boiler consumes over 4,860 lbs. of natural gas each hour while exhausting 10,938 lbs. of high temperature water vapor each hour. The water vapor in the flue gas contains over 10.6 MMBtu/hour of latent heat. As shown in Table 2, the total heat actually available for recovery is strongly dependent upon the stack gas temperature at the condensing economizer outlet.

Table 2. Exhaust Gas Energy Available from a 100,000 lb/hr Natural Gas-Fired Steam Boiler (MMBtu/hour)

Flue Gas Temperature Leaving Condensing Economizer	75˚F	100˚F	125˚F	150˚F
Sensible Heat	6.46	5.75	5.03	4.31
Latent Heat	9.51	7.00	2.01	0.0
Total Available	15.97	12.75	7.04	4.31

Note: Example in Table 2 assumes an 83% fuel-to-steam efficiency, 4% excess oxygen, a stack temperature of 300°F after feedwater economizer, a blow down rate of 4%, and a boiler feedwater temperature of 260°F. Makeup water temperature is 55°F.

Example - Assume that an indirect contact condensing economizer is retrofitted onto this 100,000 lb/hour steam boiler to heat 50% of the make-up water from 55°F to 200°F and flue gases are cooled to 100°F. At these conditions, 12.75 MMBtu/hr of total energy is available in the exhaust, of which 7.55 MMBtu/hr will be recovered to heat make-up water in the condensing economizer. More energy could be recovered if additional heat sinks are available. Given 8,000 hours per year of boiler operation, and a fuel cost of $8.00/MMBtu, the annual energy recovered is valued at:

Annual Savings = 7.55 MMBtu/hr x 8,000 hrs/yr x $8.00/MMBtu / 0.83 = $582,170