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Fuel Reductions Projects for Steam Systems

By Ed Wolfe

With today's high cost of fuel, an audit of your steam facilities offers an opportunity for significant dollar savings by recovering heat now being discharged as a waste. To obtain this goal, here are six areas which offer significant potential energy and fuel savings.

A) Return Condensate to the Boiler

B) Recovering Heat From Boiler Blowdown

C) Improve Quality of Makeup Water

D) Inspect and Repair Steam Traps

E) Insulate Steam Distribution and Condensate Return Lines

F) Feedwater Economizers for Flue Gas Heat Recovery

A) Return Condensate to the Boiler

Condensate is formed when steam transfers its latent heat to be used within a plant by changing its phase from gas to a liquid. The plant has the option of either discharging it to the sewer "as is" or recovering its available heat. When this heat is returned to the boiler, fuel is saved. When clean condensate (a high purity water) is returned to the boiler, less makeup water is required resulting in less boiler blowdown and lower boiler water treatment costs. The heat in dirty condensate can be recovered by use of a heat exchanger with the cold makeup water. Significant fuel savings occur as most returned condensate is relatively hot (150°F to 250°F), reducing the amount of cold makeup water (50°F to 60°F) that must be heated.

Example: Amount of heat recoverable in 50 k#/hr condensate at a temperature of 200°F.

Enthalpy of 200°F Condensate = 168 Btu/#

Total Heat in Condensate 168 Btu/# X 50 k#/hr = 8.4 x 10^6 Btu

Enthalpy of 55°F Makeup Water = 23 Btu/#

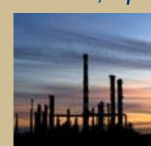
Total Heat in Makeup Water 23 Btu/# X 50 k#/hr = 1.2 x 10^6 Btu

Total Heat Recovered = 7.2 x 10^6 Btu

Training

Presented a three-day onshore crane safety course for a refining client in Europe.

Process, Operation & Safety



Conducted review of domestic delayed coker incident, which incurred fractionators tray damage, and selected delayed coker operating procedures. This resulted in some corrective action, such as supplemental training and improvements to operating procedures, plus safeguards to minimize similar incidents from occurring in the future.

Reliability & Maintenance

Providing onsite pre-turnaround planning and engineering management consulting support for a coker unit scheduled for a turnaround in Spring 2009. Alternative mechanical procedure and sequencing recommendations were made that will reduce the turnaround time by several days from the original plan.

Fuel Savings: Knowing the amount of Btu in each unit of purchased fuel, the savings can be calculated.

Makeup Water Savings: Use of 50 k#/hr of clean condensate as boiler feedwater reduces the amount of makeup water by 100 gpm. Since this condensate is high purity distilled water the boiler water will need less chemical treatment and the blowdown will be reduced significantly, also reducing heat losses.

B) Recovering Heat From Boiler Blowdown

Fuel savings realized by recovering heat from boiler blowdown may be substantial as the temperature and pressure of the blown-down water is the same as that of the steam. Blowdown waste heat can be recovered using a flash tank in combination with a heat exchanger. Controlling the operating pressure in a flash tank allows a portion of the blowdown water to be converted into 15 psig pressure steam. This low pressure steam may be used in deaerators or for a heating steam. The water remaining in the flash tank is then routed through a heat exchanger to heat the boiler cold makeup water. Any boiler with continuous blowdown exceeding 5% of the steam rate is a prime candidate for waste heat recovery. Even larger energy savings are possible with high-pressure boilers.

Example: Amount of Heat Recovered From Boiler Blowdown Water

Amount of heat recoverable in 5,000 #/hr of boiler blowdown from a 100,000 #/hr 150 psig boiler with a blowdown rate of 5%.

Enthalpy of 366°F boiler blowdown water = 338 Btu/#

Total heat in blowdown 338 Btu/# X 5000 k#/hr = 1.69 x 10^6 Btu/hr

Total Heat in Cooled Blowdown Discharged to Sewer

Assume effluent temperature of blowdown from heat exchanger is 10°F higher than makeup with water temperature 55°F = 65°F

Enthalpy of 65°F cooled blowdown water = 33 Btu/#

Total Heat in cooled blowdown 5000 k#/hr X 33 Btu/# = 0.165 Btu/hr

Heat Recovered: 1.69 Btu/hr x 10^6 – 0.165 Btu/hr x 10^6 = 1.52 Btu/hr x 10^6

Fuel Savings: Knowing the cost of Btu in each unit of purchased fuel, the savings can be calculated.

Amount of Steam Flashed in 15 psig Flash Tank

Total Heat in Blowdown water in 15 psig Flash Tank @ 250°F

Enthalpy of 250°F boiler blowdown water = 219 Btu/#

Heat in blowdown water 5000 k#/hr X 219 Btu/# = 1.10 X 10^6 Btu/hr

Available heat for flashing 15 psig steam

Heat in 150 psig blowdown = 1.69 x 10^6 Btu/hr – 1.10 x 10^6 Btu/hr = 0.59 x 10^6 Btu/hr

Each pound of 15 psig steam contains 1164 Btu/#

Amount of 15 psig steam available 0.59 x 10^6 Btu/hr/1164 Btu/# = 507 #/hr of 15 psig steam

C) Improve Quality of Boiler Makeup Water

Two fuel reduction benefits may result by upgrading the quality of the boiler makeup water. First is less boiler blowdown, and second is the reduction of heat losses from excessive scale on the boiler tubes.

Although the amount of heat available from reducing blowdown is minimal when an existing heat recovery system is in place as described above, significant fuel savings can be realized in using higher quality makeup. Also, savings will result in using less fresh water and a reduction in waste water and the chemicals required for boiler water treatment. The real energy and fuel savings comes from keeping the heat transfer surfaces on the water side of the boiler tubes free from scale. Deposits occur when calcium, magnesium, and silica, commonly found in most makeup water supplies, react to form a continuous layer of scale. Scale possesses a thermal conductivity much less than bare steel. Even thin layers of scale serve as an effective insulator and retard heat transfer. The result is overheating of boiler tube metal, tube failures, and loss of energy efficiency. Fuel waste due to boiler scale may be as high as 7% for an iron silica scale 1/32 inches thick and 6% for a normal calcium scale 1/16 inches thick.

To determine if there is excessive scale, boiler tubes should be inspected when the unit is shut down for maintenance or repairs. If the scale thickness is greater than 1/32 inch, consider auditing your makeup water treatment system. Since each boiler makeup water treatment system is unique, requiring a tailor-made treatment program, it is necessary to do a detailed evaluation of an existing systems to determine whether the design is at optimum fuel efficiency. Tools to do this audit may be found in Carmagen's Training Course No. 1215, "Boiler Water Treatment Practice."

D) Inspect and Repair Steam Traps

There are many types of steam traps: thermostatic, float, and bucket traps, all prone to allowing live steam to escape into the condensate return system. In a 300 psig steam system, a failed steam trap with a trap orifice 1/8 inch in diameter will lose 145 lbs/hr of live steam, with a 3/16 inch orifice losing 326 lbs/hr.

Plants having over 100 steam traps should have a weekly scheduled testing program, keeping the leaking ones to less than 5%. This program should determine if they are functioning properly and not cold plugging, or failing in an open position and allowing live steam to be lost to the atmosphere. There are four basic ways to test steam traps: temperature, sound, visual, and electronic. The steam trap vendors can be of help in developing this maintenance program.

E) Insulate Steam Distribution and Condensate Return Lines

Installing 90% efficient insulation can reduce energy losses by 90% and help ensure proper steam pressure at plant equipment. Any surface over 120°F should be insulated, including boiler surfaces, steam and condensate return piping, and fittings. Removable insulating jackets are also available for valves, flanges, steam traps, and other fittings.

Insulation frequently becomes damaged or is removed during maintenance and never replaced after steam system repair. Damaged or wet insulation should be immediately replaced. Causes of wet insulation include leaking valves, external pipe leaks, tube leaks, or leaks from adjacent equipment. The North American Insulation Manufacturer's Association has developed a software package (3EPlus) that determines the optimum thickness for a wide variety of insulating materials. Outputs include the simple payback period, surface heat loss, and surface temperature for each specified insulation thickness. 3EPlus is available at no cost through the internet.

F) Feedwater Economizers for Flue Gas Heat Recovery

A feedwater economizer reduces boiler fuel requirements by transferring heat from the flue gas to the boiler feedwater. Boiler flue gases are often discharged to the stack at temperatures 100°F to 150°F higher than the temperature of the generated steam. The lowest temperature to which flue gases can be cooled depends on the type of fuel used: 250°F for natural gas, 300°F for coal and low sulfur content fuel oils, and 350°F for high sulfur fuel oils. These limits are set to prevent condensation with the possible corrosion of the stack due to sulfuric acid.

By recovering the flue gas waste heat, using an economizer will reduce fuel requirements by 5% to 10% and pay for itself in less than two years.

<u>Example</u>

A boiler generates 52,000 lb/hr of 150 psig steam by burning natural gas with 15% excess air. Condensate is returned to the boiler and mixed with makeup water to yield 117°F feedwater. The boiler feedwater is further heated to 250°F in a deaerator using flashed steam from the boiler blowdown. The stack temperature is measured at 500°F. Determine the energy savings that will be achieved by installing an economizer.

From the steam tables, the following enthalpy values are:

For 150 psig saturated steam: 1,195 Btu/lb

For 250°F feedwater: 218 Btu/lb

Boiler thermal output = 52,000 lb/hr X (1,195 – 218) Btu/lb = 50 million Btu/hr

The recoverable heat corresponding to a stack temperature of 500°F and a natural gas fired boiler using 15% excess air with the flue gas temperature cooled to 250°F equals 4.6 million Btu/hr as shown in the US Department of Energy's Table.

Recoverable Heat from Boiler Flue Gases

Initial Stack Gas Temperature, °F	Recoverable Heat, MMBtu/hr			
	Boiler Thermal Output, MMBtu/hr			
	25	50	100	200
400	1.3	2.6	5.3	10.6
500	2.3	4.6	9.2	18.4
600	3.3	6.5	13.0	26.1

Based on natural gas fuel, 15% excess air, and a final stack temperature of 250°F.

The source for this article is "*Improving Steam System Performance*," a book by the U.S. Department of Energy, available on the Internet.

Ed Wolfe has over 35 years experience as a water treatment specialist. His background includes broad-based project engineering experience in all aspects of the planning, implementation, and start-up of computer-controlled water and wastewater treatment plants. His assignments have ranged from pilot plant scale to the world's largest boiler feedwater treatment facility. Please contact Jerry Lacatena if you'd like more information on Carmagen's expertise in these areas.