Reducing Energy Cost Through Boiler Efficiency

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Boiler Efficiency – Presentation Overview

- Definitions
- Operations
  - Employee
  - Suppliers
- Energy Savings
  - Boilers & Equipment
  - Monitoring Equipment
  - Routine Audits
Boiler Efficiency – Why is it important?

- Cost of boiler fuel is 2.5–3 times higher than 4 years ago and continues to rise.
- May be the highest single feed manufacturing cost??
- Competition knows it is important!!
  - Company feed mill managers
  - Agri-stats
- BOSS wants lower costs!!!
Boiler Efficiency

• Input Energy
  • Fuel oil
  • Natural Gas
  • Propane

• Output Energy
  • Process Steam
General Boiler Information

- 1 boiler horse power = 42,000 BTUs of INPUT
- 1 pound of steam = 1,200 BTUs of INPUT fuel
- Typical boiler efficiency = 75-85%
- New high efficiency near 90%

Fuel sources:
- Natural Gas = 1,031 BTU/ft³
- Propane = 91,000 BTU/gal
- Fuel Oil = 139,000 BTU/gal
A Fable

A feed mill manager once went to a wise man for help in improving his inefficient, unprofitable feed milling operation. The wise man wrote a charm on a piece of paper and sealed it in a box that he gave to the manager.

“Carry this box into every part of your mill three times each day for a year,” he told him. The mill manager did so.

In the morning he carried the box and its charm into the warehouse and found a laborer fast asleep on a pile of sacks instead of working. At noon, he carried it up to the milling floor, he noticed a leak in a spout that was contaminating a bin of grain. He also spotted a hot bearing and called a mechanic to grease it. At night, he carried the box to the packing room and found his employee overfilling the bags.

Everyday, as he took the box and its charm from place to place in the mill he found things to correct. At the end of the year, he returned the box to the wise man.

“Let me keep the charm for one more year,” he begged. “My mill is more efficient and more profitable than it has every been before”

The wise man smiled and took the box. “I’ll give you the charm itself,” he said. He broke the seal, lifted out the piece of paper and handed it to the mill manager.

On it was written:  

**IF YOU WANT THINGS TO PROSPER, LOOK AFTER THEM YOURSELF.**

Robert McEllhiney 1928 – 2006, FMT IV
Boiler Room Operation

- A feed mill manager MUST be committed to the boiler room.
- Cost
  - Fuel
  - Supplies
- Pellet Mill Operation
  - Throughput
  - Pellet Quality
  - Plugs
Keys to an Efficient Boiler Operation

- Employees
  - Training, Mentors, Personal Commitment

- Quality Suppliers
  - Boiler Company, Chemical, Water Softener

- Equipment Operating Properly
  - Water softener
  - Boiler (tubes, burner, air)
  - Heat recovery (blowdown, economizers)
  - Controls (integrated, low fire)

- Priority of Manager
  - Daily Routine
### Measuring and Improving Boiler Efficiency—Advanced

**June 5, 2008**  
8:30 a.m. - 4:30 p.m.

McKinnon Conference & Training Center, NC State University, Raleigh, NC

Register Deadline: May 23, 2008

#### Why You Should Attend

By attending you will receive a thorough explanation of the operation of firetube and watertube boilers and the significant variables that affect the efficiency of these boilers. You will learn the most cost-effective ways for improving a boiler’s efficiency for both oil and gas-fired units, as well as coal and wood-fired situations. You will also leave with an understanding of principles and methods for conserving.

#### Attend and You’ll Learn

- Boiler efficiency calculations
- Fuel-combustion relationship
- Heat recovery opportunities
- Cool-down correction
- Proper water treatment to reduce blowdown

#### Who Should Attend

Boiler operators/engineers and people responsible for the maintenance, operation, and supervision of industrial/commercial/institutional boilers and steam systems.

#### Attend and You’ll Receive

- 7.0 Engineering Professional Development Hours (PDHs)
- A networking luncheon
- A Certificate of Attendance

#### Instructor

Dr. Herbert M. Erskine
(see his biography on page 7)

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Boiler Training Class

- Mentors
- Daily routines
  - Sampling
    - TDS
    - O₂
    - pH
  - Blowdown

[http://www.ies.ncsu.edu/events/eventdesc.cfm?cid=1339&cp=29](http://www.ies.ncsu.edu/events/eventdesc.cfm?cid=1339&cp=29)
Boiler Room Suppliers

- Boiler company
  - Routine visit
  - Annual audit
- Boiler chemicals
  - Monthly visits
  - Testing & adjustments
- Water softener
  - Monthly visits
ENERGY SAVINGS
Industrial Boilers

600 BHP

2,400 BHP

200 BHP

50 BHP
Boiler Energy Balance

- Heat loss in flue gases: 18%
- Radiation and convection heat loss: 4%
- Energy input: 100%
- Energy in fuel
- Boiler
- Energy output (boiler thermal efficiency): 75-77%
- Energy in heating medium (e.g. steam)
- Heat loss in blowdown: 3%
Types of Boilers

Firetube - Dry-back

Firetube – Wet-back

Watertube

Electric Boiler

http://www.spiraxsarco.com/resources/, 3/1/08
Energy Savings – Boiler Type

The cost to operate a boiler is 4 times the initial installation cost.

<table>
<thead>
<tr>
<th>Boiler Efficiency</th>
<th>Oil $2.75/gal</th>
<th>Natural Gas $1/therm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Operating 70%</td>
<td>$1,400K/yr</td>
<td>$717K/yr</td>
</tr>
<tr>
<td>75%</td>
<td>-92K</td>
<td>-48K</td>
</tr>
<tr>
<td>80%</td>
<td>-173K</td>
<td>-89K</td>
</tr>
<tr>
<td>85%</td>
<td>-245K</td>
<td>-126K</td>
</tr>
</tbody>
</table>

Assuming 500 BHP @ 3000 hrs/yr
Energy Savings - Scaling

Boiler Water

Scale

Tube Metal

Hot Gases

metal = **good** conductor of heat

scale = **poor** conductor of heat

Modified Dale Williams, 2006 Chem Treat
## Energy Savings – Scaling

<table>
<thead>
<tr>
<th>Scale Thickness (Inches)</th>
<th>Additional Fuel Usage (Percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/32</td>
<td>8.5%</td>
</tr>
<tr>
<td>1/25</td>
<td>9.3%</td>
</tr>
<tr>
<td>1/20</td>
<td>11.1%</td>
</tr>
<tr>
<td>1/16</td>
<td>12.4%</td>
</tr>
<tr>
<td>1/8</td>
<td>25.0%</td>
</tr>
<tr>
<td>1/4</td>
<td>40.0%</td>
</tr>
<tr>
<td>3/8</td>
<td>55.0%</td>
</tr>
<tr>
<td>1/2</td>
<td>70.0%</td>
</tr>
</tbody>
</table>

Example - $750K fuel bill with 1/16” scale cost $93K.
Energy Savings - Economizer

- Example – 500 hp Boiler
  - 20,000,000 BTU
  - 5% recovered with economizer
  - 1,000,000 BTU’s
  - Water returned to boiler

http://www.energysolutionscenter.org 3-5-08
Boiler Blowdown

Why do we blowdown?

- To removed the dissolved solids that have concentrated in the boiler due to evaporation.
How Does Blowdown Affect the Plant?

- **Too Much Blowdown**
  - Increased fuel costs
  - Increased water costs
  - Increased chemical costs

- **Too Little Blowdown**
  - High TDS will occur, resulting in:
    - Foaming
    - Priming
    - Corrosion
    - Scale
Energy Savings – Blowdown Heat Recovery

- Blow down is 5-10% of boiler capacity
- Recovery systems can capture steam that would go to the drain
- Pre-heat make up water
- Reduces water usage to cool the blow down prior to the drain

http://www.energysolutionscenter.org 3-5-08
Energy Savings – Steam Traps

<table>
<thead>
<tr>
<th>Leaking Steam Trap Discharge Rate</th>
<th>Steam Loss (lbs/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steam Pressure (psig)</td>
</tr>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td>1/32</td>
<td>0.85</td>
</tr>
<tr>
<td>1/16</td>
<td>3.4</td>
</tr>
<tr>
<td>1/8</td>
<td>13.7</td>
</tr>
<tr>
<td>3/16</td>
<td>30.7</td>
</tr>
<tr>
<td>1/4</td>
<td>54.7</td>
</tr>
<tr>
<td>3/8</td>
<td>123</td>
</tr>
</tbody>
</table>

From the Boiler Efficiency Institute. Steam is discharging to atmospheric pressure.

Example: 52.8 lbs/hour x 8,760 hours per year x $9 per 1,000 pounds = $4,162 per year.
Energy Savings - Insulation

### Heat Loss per 100 feet of Uninsulated Steam Line

<table>
<thead>
<tr>
<th>Distribution Line Diameter (inches)</th>
<th>Heat Loss per 100 feet of Uninsulated Steam Line (MMBtu/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Steam Pressure (psig)</td>
</tr>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td>1</td>
<td>140</td>
</tr>
<tr>
<td>2</td>
<td>235</td>
</tr>
<tr>
<td>4</td>
<td>415</td>
</tr>
<tr>
<td>8</td>
<td>740</td>
</tr>
<tr>
<td>12</td>
<td>1,055</td>
</tr>
</tbody>
</table>

Based on horizontal steel pipe, 75°F ambient air, no wind velocity, and 8,760 operating hr/yr.

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http://www.energysolutionscenter.org 3/9/08
Energy Savings – Steam Piping

- New vs. Old systems
- Direct runs
- Check for leaks
- Check valves
- Check traps
- Check insulation
Energy Savings - Steam Leaks

Assumptions:
Model=Compressible flow analysis, sharp edge orifice leak
Cost=$9.50/1,000 pounds of steam
Pressure=150 psig at 500 °F

Leak Size
- 1" Monthly Energy Costs
  - $26,083
- 3/4" $14,668
- 1/2" $6,519
- 1/4" $1,630
- 1/8" $409

Losses through

Source: Steam System Survey Guide
ORNL/TM-2001-263, p. 6-2

http://www.energysolutionscenter.org 3/9/08
Flue Gas Analysis

- Tables available by fuel source
  - Net stack temperature
  - Excess % Air
  - Excess % O₂
  - Excess % CO₂

www.natcomonline.com

http://www.energysolutionscenter.org 3/9/08
Energy Savings – Computer Automation

Integrated Boiler Room Control System

Touch it, feel it, see it...from anywhere in the world.

Courtesy of Cleaver Brooks
Energy Savings – Computer Automation

L35E Standard Offering

- Compact Logix PLC L35E Processor
- 10” Color Touch Screen
- Integrated \(O_2\) Trim and Monitoring
- Integrated Parallel Positioning
- PLC Based Firing Rate Control
- 4 User Analog Inputs
- Level Master Interface
- Two Boiler Lead/Lag Programming
- Remote Set Point & Modulation
- Expanded Annunciation & 3 User Discrete IN’s
- CB 780 Burner Management
- Thermal Shock Protection
- Dual Set Points
- Stack Temp With High Limit Cut Off

Control Panel

Courtesy of Cleaver Brooks
Energy Savings – Computer Automation

Status Overview Screen

Alarm: THERMOCOUPLE CHANNEL 1 FAILURE
RUN

Flue Gas
320 F Out
300 F In

Combustion Air Temp
140°F

Combustion Fan
3400 RPM
23.7 kW

Combustion Air Pressure
14” wc

Fuel Selected
Natural Gas

Efficiency
83 %

Oxygen
3 %

Pressure
126 psi

Set Point
130 psi

Boiler On

Keypad/LLag

Running

CLEAVER-BROOKS HAWK ICS CONTROL SYSTEM
ID: Boiler #1
S/N: 01-300296
Elapsed Time: 38.5 hrs
No. of Cycles: 15

Firing Rate
Water
Feedwater
Water Level
3.0 “LWCD

IP ADDR. 192.168.1.100

Boiler Overview
Burner Control
Firing Rate
Blower VSD
Water Level
2 Boiler Lead/Lag
Alarm Silence
Alarm History

Courtesy of Cleaver Brooks
Automation Equipment

Monitoring Capabilities
Include:
- Operating parameters, faults and selected I/O's
- Stack temperature
- Combustion air temperature
- Combustion fan RPM
- Combustion air pressure
- Efficiency
- O2
- Steam pressure and flow
- Water temperature
- Fuel flow
- Water level
- Firing rate
- Faults and fault history

Optional Features and functions include:
- Parallel control of fuel and air using motor actuator drives; minimizing linkages.
- Water level monitoring and alarming
- O2 monitoring and/or trimming
- Ethernet and internet communication
- E-mailing, paging and on-line trouble shooting
- Building management system interfacing
- Backlit touch screen (optional)

www.cleaver-brooks.com/
Regular Visits/Audits

- Audits
  - Internal/Company
  - Chemical Company
    - Feed water
    - Boiler wastewater
  - Water Softener Company
  - External Company
    - DOE, Extension, Boiler Supplier
Resources

- Feed Manufacturing Technology V
  - www.afia.org

- Boiler Burner
  - http://www.energysolutionscenter.org/BoilerBurner/Eff_Improve/Inde
-x/Index_Boiler_Eff_Start.asp
  - www.energysolutionscenter.org

- Department of Energy
  - www.doe.gov

- Cleaver Brooks
  - http://www.cleaver-brooks.com/

- Cleaver Brooks Steam Calculator
Questions

NCSU Feed Mill Educational Unit