LOW TEMPERATURE ECONOMISERS FOR WASTE HEAT RECOVERY

Presentation by Mike Wignall

Group Overseas Operations Director

Greens Holdings

February 2012
NTPC CONFERENCE

Greens Holdings/Greens Power

Waste Heat Recovery with Low Temperature Economisers

Types of Economisers
Greens Power Limited

UK based Company
- 178 years old
- Manufacturing Bases in Shanghai
- $136 million turnover
Greens History

Edward Green

Founder

1799 - 1865
Patented Fuel Economiser in 1845
Operating Centres Today

- Wakefield, UK

- Shanghai, China
WASTE HEAT RECOVERY

TECHNICAL BACKGROUND
Why Flue Gas Heat Recovery Required

1. Normal air pre-heater can not help us to reduce the flue gas temperature satisfactorily (recover more heat).

2. Due to soaring fuel price, all power plant facing serious pressure to increase the boiler efficiency. Flue gas loss is the major loss for the boiler, so recovering as more heat as we can from flue gas seemed to be a short cut way.

3. Large quantity cooling water is required to cool the flue gas before the desulphurization for those boilers without GGH.

4. Steam air pre-heater require some steam which will reduce the efficiency of the power plant.
TECHNICAL BACKGROUND
LOW TEMPERATURE
ECONOMISERS

• “OLD” TECHNOLOGY
• SPACE CONSTRAINTS
• PROBLEMS OF “DUST CLOGGING”
• POSSIBLE CORROSION PROBLEMS
• PRESSURE DROP PROBLEM
• STRUCTURAL STEEL COST
Technical Solution for Thermal Power Plant
Gas Heat Recovery System

System Principle

Diagram showing the flow of flue gas through different components such as the rotary air preheater, electrostatic precipitator, flue gas cooler, limestone tower, and cooling tower.
WASTE HEAT RECOVERY

THE GREENS SOLUTION

4 POSSIBLE SCENARIOS
COMMON ARRANGEMENTS FOR GAS HEAT RECOVERY SYSTEMS

Scenario 1 Condensate Heater
- Boiler
- Air Pre-heater
- ESD
- Condensate
- ID Fan
- FGD
- Stack

Scenario 2 Two stage Condensate Heater
- Boiler
- Air Pre-heater
- ESL
- Condensate
- ID Fan
- FGD
- Stack

Scenario 3 Air Pre-heater
- Boiler
- Air Pre-heater
- ESD
- Condensate
- ID Fan
- Heating Water
- FGD
- Stack

Scenario 4 GGH
- Boiler
- Air Pre-heater
- ESD
- Circulating Water
- ID Fan
- FGD
- Stack
Typical Scenarios for Waste Heat Recovery

1. Scenario 1, Condensate or Heating water heater
   - The flue gas heat recovery system will heat the condensate, then the steam consumption for the LP heater will be reduced, and then the cycle efficiency will be higher.
   - Or, the flue gas will heat hot water which could be use for heating or air conditioning.

2. Scenario 2, Two stage Condensate or Heating Water Heater
   - Another set recovery device is located front of the ESP to reduce the flue gas temperature and then the efficiency of the ESP will be higher.
   - More dust accumulation risk for the device front of ESP

3. Scenario 3, Air pre-heater
   - The flue gas heat recovery device will provide hot water to preheat the combustion air.
   - Not suitable for summer or warm area.

4. Scenario 4, Gas Gas Heater
   - The cold gas at outlet of FGD will cool the flue gas at inlet of FGD to reduce the flue gas temperature.
   - No heat recovery
   - Complicated system
Location

- Desulfurization Tower
Field Installation
OPERATIONAL ISSUES WITH EXTENDED SURFACE ECONOMISERS
Operation

- Clogging Risk
- Ash and high viscosity substance (gypsum slurry)
- Corrosion Risk
- Last-stage heat exchanger operated under dew-point will have high corrosion risk
GREENS SOLUTION

• TOTAL SYSTEM DESIGN REVIEW

+ 

• GREENS ECONOMISER
GREENS SOLUTION

• Anti-corrosion Countermeasure
  • Use higher grade Material
  • Use thick tubes, corrosive allowance more than 3mm
  • Use higher ribbed tube bundles, increase surface temperature, reduce contact between bare tube and flue gas
GREENS SOLUTION

ANTI-CLOGGING

- LOCATE AFTER ESP
- USE DOUBLE H FIN
- "IN LINE "ARRANGEMENT
GREENS-PROVEN SUCCESS

9 off Projects

3 in Operation-CHINA

6 in Manufacturing/Installation Phase
GREENS SUCCESS

- SHANGHAI WUJING (600MW) - 12 MONTHS OPERATION

- JIANSU LIGANG (350MW) - 18 MONTHS OPERATION

- 1.4g/KWh to 1.8g/KWh COAL SAVED

- PAY BACK ON INVESTMENT 3.5 YEARS (APPROX)
GREENS SUCCESS

CHINA REFERENCES - MAINLY TO HEAT CONDENSATE

INDIA (UCCHPINDA, 4 x 360MW) USED TO DRIVE 800 TR VAHP - BEING DELIVERED
GREENS SUCCESS

SPACE PROBLEM?

ACID DEW POINT PROBLEM?

“CLOGGING” PROBLEM?

PRESSURE DROP PROBLEM?

EROSION PROBLEM?
GREENS – ANSWER TO THESE PROBLEMS

STEEL “H” ECONOMISERS
named steel h because the original fin resembled the capital letter ‘h’

steel h is an extended fin tube on machines designed and built in house to our own specification.

50 years of experience and development.

computer controlled for consistent weld quality.
STEEL H PLATE FIN

- In Line Tube Arrangement with Straight Gas Passages Ensure Low Fouling and Sustained High Efficiency with Dirty Fuels
- More Effective Soot blowing
- Compact Size
- Low Pressure Loss
- Less Tubes and Weight
- Lower Boiler Costs
- Proven Heat Transfer Rates
- Double ‘H’ Inherent Stiffness
Heating Surface Area
M2 in 1 Cubic Metre of Space.

Heating Surface
[ m² ]

PS            CFS            HF           Steel H       Double Stl H
Single steel H
Helical Fin
Steel H vs Spiral/bare Tube

Steel H is more compacted and low pressure drop.
Research & Development

Fins placed in areas of highest heat transfer.

Fin weld on sides of tube where maximum heat transfer takes place.

Fin material not placed where dust can accumulate above and below the tube.

Fin sizes optimised for efficient use of material.
PRECISE INDEXING
PURPOSE BUILT MACHINES
Drax Power Station, UK
6 x 660 MW - Supplied 1\textsuperscript{st} 1970
Babcock Boiler
NANAO Power Station
1 x 700 MW – Supplied 1997
IHI Boiler, JAPAN
DATTLEN Power Station GERMANY
1x 1100 MW
HITACHI Boiler
GREENS ECONOMISERS- STEEL “H” BENEFITS

- Improved Performance
- Lower Capital Costs
- Lower Running Costs
The Kvaerner 274 MW$_{th}$ HYBEX™ boiler installed at the Edenderry plant in Ireland.

PEAT FUEL BFB BOILER WITH GREENS STEEL H ECONOMISER
CASE SUMMARY

ESB Ireland wanted to know how a plain steel economiser would compare commercially and technically to a Steel H Economiser.

The following is an extract from the presentation made by Greens.
REQUIRED PERFORMANCE DETAILS

- 274MW Peat Fired BFB Boiler.
- Maximum gas velocity 15 m/s.
- Economiser thermal duty 30.5MW
- Chamber Size 6100mm wide x 10700mm long.
- 643 tonnes/hr gas in at 422°C out 283 °C.
- 336 tonnes/hr water in at 258°C and 174.5 bar.
## STEEL H CASE STUDY

### ARRANGEMENT

<table>
<thead>
<tr>
<th></th>
<th>Plain Tube</th>
<th>Steel ‘H’</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEEL ‘H’</td>
<td><img src="image" alt="Diagram" /></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td><img src="image" alt="Diagram" /></td>
<td></td>
</tr>
<tr>
<td>PLAIN TUBE</td>
<td><img src="image" alt="Diagram" /></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube OD, mm</td>
<td>42.4</td>
<td>38.1</td>
</tr>
<tr>
<td>Tube Effective Length, mm</td>
<td>9,000</td>
<td>9,400</td>
</tr>
<tr>
<td>Tube pitch, h x v, mm</td>
<td>90 x 90</td>
<td>79 x 79</td>
</tr>
<tr>
<td>Rows wide</td>
<td>56</td>
<td>70</td>
</tr>
<tr>
<td>Rows High</td>
<td>124</td>
<td>36</td>
</tr>
<tr>
<td>Total economiser height, m</td>
<td>16.600</td>
<td>4.685</td>
</tr>
</tbody>
</table>

Case Study 1
<table>
<thead>
<tr>
<th></th>
<th>Plain Tube</th>
<th>Steel ‘H’</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ARRANGEMENT</strong></td>
<td>[Diagram]</td>
<td>[Diagram]</td>
</tr>
<tr>
<td><strong>STEEL ‘H’ v PLAIN TUBE</strong></td>
<td>[Diagram]</td>
<td>[Diagram]</td>
</tr>
<tr>
<td>Fin Pitch, mm</td>
<td>N/A</td>
<td>23.5</td>
</tr>
<tr>
<td>Total tube used, m</td>
<td>66,525</td>
<td>25,508</td>
</tr>
<tr>
<td>Total Heating Surface, m²</td>
<td>8,324</td>
<td>12,042</td>
</tr>
<tr>
<td>Number of Banks</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Weight Tonnes</td>
<td>446</td>
<td>240</td>
</tr>
</tbody>
</table>

**Case Study 1**
<table>
<thead>
<tr>
<th></th>
<th>Plain Tube</th>
<th>Steel ‘H’</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flue Gas Velocity, max m/s</strong></td>
<td>15.1</td>
<td>15.0</td>
</tr>
<tr>
<td><strong>Pressure loss, gas side mm WG</strong></td>
<td>160</td>
<td>65</td>
</tr>
<tr>
<td><strong>Feed water velocity avg, m/s</strong></td>
<td>1.35</td>
<td>1.35</td>
</tr>
<tr>
<td><strong>Pressure loss, water side, bar</strong></td>
<td>2.6</td>
<td>0.9</td>
</tr>
</tbody>
</table>
# STEEL H CASE STUDY

## TOTAL OPERATIONAL COSTS

### STEEL ‘H’ v PLAIN TUBE

Cost of operation assuming 15 years at 8600 hours and Rs 3.0 kWh

<table>
<thead>
<tr>
<th></th>
<th>Plain Tube</th>
<th>Steel ‘H’</th>
</tr>
</thead>
<tbody>
<tr>
<td>FANS</td>
<td>23,33,00,000</td>
<td>9,66,00,000</td>
</tr>
<tr>
<td>PUMPS</td>
<td>2,62,00,000</td>
<td>85,52,000</td>
</tr>
<tr>
<td>TUBE CLEANING (STEAM)</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>TOTAL OPERATIONAL COSTS</td>
<td>25,95,00,000</td>
<td>10,51,52,000</td>
</tr>
</tbody>
</table>

### TOTAL OPERATIONAL SAVING WITH STEEL H

154,348,000

### ANNUAL OPERATIONAL SAVING WITH STEEL H

10,289,000
CASE SUMMARY

IHI in Japan had an existing coal fired boiler that was under performing. IHI failed to meet customer guarantees. It was decided that if it was possible to improve the economiser performance the overall boiler efficiency would be increased.

The problem was there was no additional space to add extra heating surface in the chamber so Greens supplied a Steel H Retrofit Economiser.

PROJECT: 1 X 600 MW NAKOSO POWER STATION, JAPAN
GREENS STEEL H CASE STUDY

Section of Plain Tube Economiser

Section of Steel H Economiser

Case Study 2
<table>
<thead>
<tr>
<th>DETAILS</th>
<th>PLAIN TUBE</th>
<th>STEEL H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber Size</td>
<td>22413 wide x 5555 long x 1600 high</td>
<td></td>
</tr>
<tr>
<td>No. of Tubes</td>
<td>3232</td>
<td>2288</td>
</tr>
<tr>
<td>Rows</td>
<td>202 rows (22110mm)</td>
<td>202 rows (22205mm)</td>
</tr>
<tr>
<td>High</td>
<td>16 rows (1483mm)</td>
<td>11.3 rows (1100mm)</td>
</tr>
<tr>
<td>Gas Temp In °C</td>
<td></td>
<td>488.33</td>
</tr>
<tr>
<td>Gas Temp Out °C</td>
<td>423.23</td>
<td>402</td>
</tr>
<tr>
<td>Water Temp In °C</td>
<td></td>
<td>278</td>
</tr>
<tr>
<td>Water Temp Out °C</td>
<td>308.34</td>
<td>321.1</td>
</tr>
<tr>
<td>Duty KW</td>
<td>26672</td>
<td>38674</td>
</tr>
</tbody>
</table>
CONCLUSION

The Steel H Unit provided a 45% increase in duty and at the same time an effective heating surface for use in boilers with high dust laden fuels.

RESULT

IHI placed the order for a Steel H unit with Greens
Greens Power High Ash Fuel References (selection from GPL data base)

<table>
<thead>
<tr>
<th>Power Station</th>
<th>Ash content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tarong, Australia</td>
<td>25% - 32%</td>
</tr>
<tr>
<td>Vales Point, Australia</td>
<td><strong>34% - 40%</strong></td>
</tr>
<tr>
<td>Yue-Yang, China</td>
<td>19.64% - 24.6%</td>
</tr>
<tr>
<td>Dalian, China</td>
<td>19.77% - 29.77%</td>
</tr>
<tr>
<td>Dandong, China</td>
<td>19.19% - 28.18%</td>
</tr>
<tr>
<td>Ho-Ping, China</td>
<td>12% - 16.5%</td>
</tr>
<tr>
<td>Linhuan, China</td>
<td><strong>48.28%</strong></td>
</tr>
<tr>
<td>Fengyi, China</td>
<td><strong>47.05%</strong></td>
</tr>
<tr>
<td>Gucheng, China</td>
<td><strong>31.45%</strong></td>
</tr>
<tr>
<td>Pha-Lai, Vietnam</td>
<td>30.32%</td>
</tr>
<tr>
<td>A Project Japan</td>
<td><strong>34% - 46%</strong></td>
</tr>
<tr>
<td>Camden, S Africa</td>
<td><strong>40%</strong></td>
</tr>
<tr>
<td>Balco, India</td>
<td><strong>45%</strong></td>
</tr>
<tr>
<td>Cadcime, Switzerland</td>
<td>&gt;30%</td>
</tr>
</tbody>
</table>

Over 70% of UK Coal Fired Power Stations contain a Greens finned tube Economiser which now burn coals with Ash contents regularly exceeding 20%
In line tube arrangements offer lowest impact angles and minimum erosion.

From the centre line of the tube the erosion rate increases to a maximum at about 30°. Then decreases rapidly as angle approaches 0°.
Tube protected while fins can collect heat. Minimum loss of heating surface.

Stainless Steel notched and formed to suit the tube. Held in place by wrap around the tube.
Gas Heat Recovery System Key Technology

Low temperature corrosion Prevention Technology

③ Use Anti-corrosive material as heat transfer tubes;

Cor-Ten & ND Steel

<table>
<thead>
<tr>
<th>Element</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cr</th>
<th>Cu</th>
<th>Sb</th>
<th>Ni/Ti</th>
</tr>
</thead>
<tbody>
<tr>
<td>10CrCuSbTi</td>
<td>0.10</td>
<td>0.41</td>
<td>0.61</td>
<td>0.012</td>
<td>0.001</td>
<td>1.01</td>
<td>0.35</td>
<td>0.06</td>
<td>/0.04</td>
</tr>
<tr>
<td>09CrCuSb</td>
<td>0.09</td>
<td>0.35</td>
<td>0.52</td>
<td>0.012</td>
<td>0.013</td>
<td>0.88</td>
<td>0.36</td>
<td>0.06</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Carbon Steel & Stainless Steel

<table>
<thead>
<tr>
<th>Element</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>S</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>20G</td>
<td>0.20</td>
<td>0.27</td>
<td>0.50</td>
<td>0.025</td>
<td>0.015</td>
<td>≤0.25</td>
<td>≤0.25</td>
<td>≤0.20</td>
</tr>
<tr>
<td>TP316L</td>
<td>0.03</td>
<td>0.55</td>
<td>1.40</td>
<td>0.037</td>
<td>0.006</td>
<td>18.2</td>
<td>10.28</td>
<td>2.07</td>
</tr>
</tbody>
</table>
Boiler electrical output 350MW
Fuel: Coal
Commissioned May 1997

Inspection carried out in April 1998.
Photograph taken looking down through tube in direction of gas flow.
Unit #3 Boiler commissioned in 1974
No cleaning before inspection.
All gas passages clear of fouling.
No ash accumulations.

Recorded on the 25th July 1999.
Unit #1 158,206 hours.
Unit #2 164,888 hours.
Unit #3 161,877 hours.
Unit #4 109,535 hours.
Unit #5 103,863 hours.
Unit #6 99,301 hours.
GREENS SUCCESS - SUMMARY

- LOW TEMPERATURE ECONOMISERS FROM GREENS WILL SAVE YOU MONEY

- PROVEN EXPERIENCE OF SAVING AS HIGH AS 1.8g/KWh OF COAL
GREENS SUCCESS - SUMMARY

SOLUTION IS:

TOTAL SYSTEM DESIGN APPROACH

+ 

GREENS STEEL “H” ECONOMISERS
Thank You