Regenerative Burners- Are They Worth It?

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Topics to be Covered:

- High Efficiency/Low NO\(_x\) Regenerative Burners
- Performance Comparison to other combustion systems
- Typical Applications
Fuel Savings and CO$_2$ Reduction

- Commercially available for over ten years, but reluctant to adopt because of:
  - High NOx emission (early versions)
  - Increased maintenance
  - Initial equipment costs

- Modern regenerative burner systems offer:
  - Reliability
  - Cost effectiveness
  - Low emissions
  - Reduced maintenance
Greenhouse gas emissions by sector USA-1997

The diagram shows the emissions of greenhouse gases from different sectors in the USA in 1997. The sectors are:

- Industry
- Transportation
- Commercial
- Residential
- Agriculture

The y-axis represents the millions of metric tons of carbon equivalent, and the x-axis represents the emission sector.
Single-Pair Regenerative Burner System
Cycling Regenerative Burners
Thermal NO$_X$ Reduction

- Our preferred technology for high temperature furnace applications combines air staging and internal POC recirculation.
- Optimizing the geometry of the burner design provides outstanding low NO$_X$ capabilities while controlling flame shape.
Thermal NO$_x$ Reduction
LumiFlame
Fuel Savings and CO$_2$ Reduction

- Burner design influences NO$_X$ emissions, but not the amount of CO$_2$ emissions.
- CO$_2$ is emitted in direct proportion to the amount of fuel consumed.
Fuel Savings and CO$_2$ Reduction

- Using *Regenerative* burner technology results in the highest available combustion efficiencies for high temperature process furnaces.
- CO$_2$ emissions are minimized.
Fuel Savings and CO$_2$ Reduction

- The extremely high air preheat improves the thermal efficiency significantly over conventional combustion systems.
- The emission of NO$_x$ can be even lower than for a low Nox cold air system, on a lbs/hr basis.
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# Fuel Savings and CO₂ Reduction
## Aluminum Melting Furnace

<table>
<thead>
<tr>
<th>Type of System</th>
<th>Air Preheat Temp °C</th>
<th>% Available Heat-HHV</th>
<th>Kg CO₂ Emitted per kcal x 10⁶ Net to Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Air</td>
<td>21</td>
<td>32</td>
<td>675</td>
</tr>
<tr>
<td>Recuperative</td>
<td>500</td>
<td>49</td>
<td>440</td>
</tr>
<tr>
<td>Regenerative</td>
<td>1130</td>
<td>72</td>
<td>300</td>
</tr>
</tbody>
</table>

**Basis:** 1300°C Furnace Exhaust Gas Temperature
Regenerative vs. Oxy-Fuel

- Both can provide high combustion efficiency and reduced GHG emissions
- Both will reduce baghouse equipment size when flue gas must be filtered
- Regenerative has higher initial cost
- Oxy/fuel has higher operating cost
Oxy-Fuel

- Significant practical drawbacks in many industrial furnace applications
  - Theoretical zero NO\textsubscript{x} emission.
  - However, nitrogen (N\textsubscript{2}) will enter the process via the fuel.
  - Tramp air into the furnace chamber in most real-world systems.
  - Oxygen costs must be factored into any comparison with regenerative firing.
Oxy-Fuel

- Oxy-fuel operating costs are often more than double those of regenerative systems.
- Best suited for dirty atmospheres where regenerators would be clogged. For example, Glass Melting.
## Operating Cost Comparison Per Hour for 10 MM BTU/hr (2.52 x 10^6 kcal/hr) Net Heat Input to Furnace

<table>
<thead>
<tr>
<th></th>
<th>Cold Air</th>
<th>Recuperative 500ºC Preheat</th>
<th>Regenerative</th>
<th>Oxy-Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equivalent Burner Input (106 kcal/hr)</td>
<td>8.09</td>
<td>5.27</td>
<td>3.54</td>
<td>3.54</td>
</tr>
<tr>
<td>Natural Gas (Nm³)</td>
<td>909</td>
<td>594</td>
<td>399</td>
<td>399</td>
</tr>
<tr>
<td>Fuel Cost (US$)</td>
<td>128.30</td>
<td>83.87</td>
<td>56.27</td>
<td>56.27</td>
</tr>
<tr>
<td>Oxygen (Nm³)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>913</td>
</tr>
<tr>
<td>Oxygen Cost (US$)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>68.13</td>
</tr>
<tr>
<td>Electrical Cost for Blowers (US$)</td>
<td>1.97</td>
<td>2.67</td>
<td>2.74</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total Cost (US$/Hr)</strong></td>
<td><strong>130.27</strong></td>
<td><strong>86.54</strong></td>
<td><strong>59.01</strong></td>
<td><strong>124.40</strong></td>
</tr>
</tbody>
</table>

**Basis:**
Efficiencies calculated on furnace exhaust gas temperatures of 1300ºC
Fuel Cost = US$4.00/MM BTU
Electric Cost = US$0.075/kWh
Oxygen Cost = US$58.00/ton (cryogenic/delivered by truck)
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Regenerative Aluminum Melter
BLOOM Regenerative Burner System
Regenerator quick disconnect
CFD analysis of aluminum melter heat flux

Contours of Total Surface Heat Flux (btu/h–ft²)

FLUENT 6.0 (3d, segregated, pdf13, ske)
Dec 20, 2002
Controls for maximum melt rate
Regenerative Fired Steel Reheat Furnace
CFD analysis of side-fired reheat furnace Flame envelopes

1150-100 with 30 Degree Port
Contours of Mole fraction of CO

May 18, 2004
FLUENT 6.1 (3d, segregated, pdf14, rke)
Resulting temperature uniformity due to regenerative burner cycling

Average Slab Surface Temp
Dual-fuel UltraLow Nox Regenerative Burner on rotary-hearth steel furnace
Batch heating furnace firing analysis

This side exhausting

This side firing

KIA – 3 to 1 Turndown
Contours of Static Temperature (c)

FLUENT 6.1 (3d, segregated, pdf13, ske)
Conclusions

- Fuel usage, CO$_2$ and NO$_X$ emissions can be reduced by applying regenerative technology to high-temperature process furnaces.
- Operating cost advantages of regenerative systems can be clearly demonstrated.
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QUESTIONS?