COMBUSTION IN ROTARY KILNS AT LKAB

Christian Fredriksson

IFRF Finnish-Swedish Flame Days
Jyväskylä 17-18 April 2013
LKAB’s iron ore products, sold to steelmills in Europe and other regions, become steels that are used in buildings, cars and many other products. The subsidiary Minelco sells industrial minerals to, among others, the refractory, foundry and oil and gas industries.
OPERATIONS

Revenue: 31,122 MSEK (2011)
Profit before tax: 14,801 MSEK (2011)
Employees: c.4,200
Owner: 100% Swedish state
PRODUCTION STRUCTURE

- Mines
- Sorting
- Concentrating
- Pelletizing
- Products
- Harbors

Kiruna

New mines Svappavaara

40 km

Grate Kiln Plant
4*approx. 50 MW
Tot about 1400 GWh

Svappavaara

NARVIK

Grate Kiln Plant
2*approx 25 MW
Tot about 400 GWh

Malmberget

LULEÅ
ROTARY KILN COMBUSTION SYSTEM

• One of the most common single burner installation
• Basically exchanging heat from hot combustion gas to bed material in the kiln
• Used to process a variety of materials, cement and lime would be the most common
COMBUSTION R&D AT LKAB

• Support function mainly for production unit
• Short and long term projects
• Co-operation with equipment suppliers/expert competence/universities

  o Pre-studies
  o Physical and numerical modeling work
  o Pilot scale trials
  o Full scale trials
  o Straight grate and grate kiln pelletizing plants

Experimental Combustion Furnace (ECF) pilot scale
Length: 14 m. Diameter: 800 mm
Fuels: Coal, oil, gas approx. 400 kW
Hot air supply: max 2600 Nm3/h at max 1250 °C
LAYOUT LKAB
KILN-SYSTEM

KIRUNA KULSINTERVERK KK2

Burner hood
KILN LAYOUT KK2

RECUP

TO COOLER
KILN AERODYNAMICS

Generic kiln

\( \lambda = 1,2-1,3 \)

- Secondary air
- Primary air + fuel
- Secondary air

Lime kiln exit
- \( \text{O}_2 = 3-5 \% \text{-vol} \)
- \( T = 600-900 \degree \text{C} \)

Iron ore pelletizing kiln

\( \lambda = 4-6 \)

- Secondary air
- Primary air + fuel
- Secondary air

Kiln exit
- \( \text{O}_2 = 14-18 \% \text{-vol} \)
- \( T = 1100-1200 \degree \text{C} \)
FLAME CHARACTERISTICS/PROFILE

- Time-temperature profile of the product pellet is important => flame profile/heat release important.
- Oxygen content near product bed, enable sintering temperature without reduction to hematite. => flame shape important, flame impingment on bed.

Kiln shell temperature profile

Kiln Shell Temperature Profile
Comparison of Weeks 48 and 50 Test Data
MEASUREMENTS IN FULL SCALE
Comparison with measurements in full scale and pilot scale

Elemental composition of fume particles (≈0.1µm) and coarse particles (≈5 µm) sampled at the transfer chute between the kiln and the PH zone in KK2 and particles sampled at point 3 in the ECF furnace.
ALKALI ELEMENTS IN FULL SCALE OPERATION

PH zone

1200 °C

Kiln

1150 °C

600 °C

Pellet bed

Condensation of alkali vapor (950-600 °C)

1700 °C

Vaporisation of alkali metals

1250 °C
NO$_x$ EMISSIONS

Increasing production ⇔ Emission regulation
Primary and secondary NOx reduction measures

SCR installed in the new pellet plant KK4. SCR could solve the problem but due to large flue gas flow, process restrictions and space requirements it is a very expensive method to use, specially on an existing plant and NOx reduction by primary methods is prioritized.
NO\textsubscript{X} – PILOT SCALE

Some results

- Burner hood modification that increases recirculation zone reduce NO\textsubscript{x}
- Fuel analysis in coal important for NO\textsubscript{x}
NO$_X$ – FULL SCALE

- Full scale trials with modifications suggested from pilot scale had in most cases little or no effect.
- Modifications did in some cases change operation of the plant with reduction of plant capacity.
- Coal feeding system/burner configuration however important for plant NOx emissions.

<table>
<thead>
<tr>
<th>Plant</th>
<th>Burner/feeding system</th>
<th>NO2 (g/MJ) approx.</th>
</tr>
</thead>
<tbody>
<tr>
<td>KK2</td>
<td>Indirect feeding with central pipe burner</td>
<td>0.48</td>
</tr>
<tr>
<td>KK3</td>
<td>Direct feeding with annular burner</td>
<td>0.75</td>
</tr>
<tr>
<td>KK4</td>
<td>Indirect feeding with central pipe + SCR</td>
<td>0.21*</td>
</tr>
<tr>
<td>SVP</td>
<td>Direct feeding with annular burner</td>
<td>0.75</td>
</tr>
</tbody>
</table>

* On annular basis
ON-GOING AND FUTURE WORK AND CHALLENGES

- Flexi Fuel – investigation new fuels
- NOx reduction
- Development measurement in full scale and pilot scale
THANK YOU FOR YOUR ATTENTION!

Acknowledgement

• ETC Energitekniskt Centrum, Piteå
• LTU Luleå University och Technology
• Swerea-MEFOS, Luleå
• FCT Combustion, Australia
• University of South Wales, Australia