The Oxyfuel Research Rig at E.ON
New Build & Technology

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Coal Research Forum AGM and Combustion Division
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Contents

1. Introduction
2. Combustion Test Facility (CTF)
3. Corrosion
4. Oxyfuel Coals and Projects
5. Plant Start Up and Emissions
6. Other Findings
7. Questions
1. Introduction

- Process Engineer
- E.ON 2006-
- Combustion, flue gas cleaning, oxyfuel
- R&D and Engineering projects
1. Introduction - ENT

- Mission is to add value to the E.ON group via operational support, by supporting the new build program and in the future by research, development and innovation.

- ~1100 employees +

- 2 main office locations

Technology Centre, Nottingham, UK

Humboldt-Forum Gelsenkirchen, Germany
## 1. Introduction - ENT

- Outage & Maintenance
- Materials & Engineering
- Pressure Parts
- Power Plant Chemistry
- Turbines
- Power Engineering Services
- Electrical Engineering
- Networks
- Fuel Sciences
- Emission Monitoring

- Plant Performance
- Flexible Operation
- Life Extension
- Biomass Fuels
- Gas Turbine Optimisation
- Steam Turbine Performance
- Business Modelling
- Stimulator Training Systems

- Risk Management
- Plant Status Review
- Maintenance Strategy
- Due Diligence
- Owner's Engineer
- Quality Assurance
- Sustainable Energy
- Technology Development
- Project Management

- New Technologies
- CCS
- Emission Modelling
- New Build Optimisation
- Nuclear Development

**Pollution Abatement**
2. 1MWth Combustion Test Facility

- Design and Planning in 1980's with commissioning in early 1990's
- Located at Ratcliffe on Soar, Nottingham, England
- Time-temperature scaled to simulate full scale plant
- Fuel flexible - Coal, biomass, oil, orimulsion, gas, additives, others
- Full combustion staging; overfire air, reburn
- Highly instrumented and controllable
- Other capabilities added such as TOMERED
- Graduated update to oxyfuel capability with FGR from 2006
- 100's data points auto logged (X, T, P, F, ...)

- Used to study fuel quality effects on combustion, emissions, slagging, fouling and corrosion. Research in LN combustion, atomisers, combustion additives, trace emissions, instrumentation, oxyfuel combustion, biomass co-firing and 100% firing, ash behaviour, heat flux...
2. 1MWth Combustion Test Facility

Original Schematic Depicting Physical Layout
2. CTF Data

<table>
<thead>
<tr>
<th>Thermal input</th>
<th>1 MW\textsubscript{th} (0.8 – 1.2MW\textsubscript{th})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Furnace</td>
<td>Horizontally fired, refractory lined, water cooled, balanced draft</td>
</tr>
<tr>
<td>Dimensions</td>
<td>1m x 1m x 3m</td>
</tr>
<tr>
<td>Burner</td>
<td>Scaled MBEL Mk III Low-NO\textsubscript{X}</td>
</tr>
<tr>
<td>Windbox temp.</td>
<td>300 to 330°C</td>
</tr>
<tr>
<td>Primary air temp.</td>
<td>80°C (70 to 90°C)</td>
</tr>
<tr>
<td>Tertiary : secondary</td>
<td>3.5:1 (1:1 to 7:1)</td>
</tr>
<tr>
<td>Overfire air</td>
<td>15% (0 to 25%)</td>
</tr>
<tr>
<td>Flue gas cleanup</td>
<td>High efficiency cyclone</td>
</tr>
</tbody>
</table>
2. CTF History and Milestones

- Commissioned 1993
- At commissioning switch to include LNB 1993
- Coal reburning added 1996
- Lignite firing 1997
- Fuel logistics upgrade 1997
- Biomass co-firing 2002
- On-line PF blending 2002
- 100% biomass firing 2004
- TOMERED loop 2005
- Oxyfuel commissioning 2006
- Oxyfuel system upgrade 2009
2. CTF Diagram Pre Oxy
2. CTF Diagram Post Oxy
2. CTF Pictures
3. Precision Metrology Corrosion Probes

- Metal Losses Determined Using Digital Image Analysis On Polished Cross Sections
- Optical & Electron Microscopy Used to Characterise Damage & Mechanisms
- Multiple port allow simultaneous testing of all important corrosion variables; tube material, metal temperature, gas environment (reducing, oxidising) and heat flux
3. Precision Metrology Corrosion Probes

Furnace Wall:
Single Specimen
Air Cooled
(15Mo3, T23, T91, HR3C, IN671)

Superheater / Reheater:
Multiple Specimens
Air Cooled
(T22, T91, E1250, Super304H, TP347HFG, HR3C, Sanicro25, IN740)
3. Superheater / Reheater Corrosion

- Comparison With T22 Pilot Scale Data Air Coal Firing
- Left – Oxy-Fuel Firing T22 Data Broadly Similar Or Slightly Elevated Rates
- Right – Oxy-Fuel Firing Austenitic Data Wide Range Responses

Cleaner Coals & Lower Heat Flux: Little Or No Attack
Dirty Coals (Higher Cl In Particular & High Heat Flux: Increased Wastage Rates – Occasionally Greater Than T22 Wastage Rates
4. Oxyfuel Coals and Projects

- Coals fired in oxyfuel
  - Kleinkopje (SA), El Cerrejon (Col.), Tselentis (SA), Thoresby, Daw Mill, Harworth, Williamson (USA), Cutacre.
  - Corrosion coals – S (0.6% - 3%+), Cl (0.02% - 0.45%)

- Projects
  - ASSOCOGS (RFCS)
  - Supplier burner testing
  - Oxycoal I (DTI)
  - “OxySOx” (TSB)
  - Oxycoal II – HFCCAT programme (TSB)
  - Project H0639C (TSB)
  - ASPECT (TSB)
5. Plant Start Up and Emissions
6. Other Findings

- Safe start up, change over and operation demonstrated
- Early, low O2 enrichment tests demonstrated poorer combustion (CO, LOI, flame detachment) compared to air firing
- More recent higher enrichment tests have shown similar to better combustion compared to than air (CO, LOI)
- High levels of CO2 in the fluegas (80%+ dry) possible
- Similar/slight increase in conc. of NOx
- Increased conc. of SO2 by factor of 3-4
- Reduced mass rates of SO2 and NO (mg/MJ fuel)
- Similar ash composition but with increased S and trace elements
- Evidence of increased superheater / reheater corrosion rates for austenitic stainless steels and nickel based alloys.
- More complex operation and control – expanded system with feedback loops.
7. Close and Questions

- Any follow on question feel free to contact me

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