Demonstration of the Doosan Babcock 40MWt OxyCoal™ Combustion System

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Research and Development Centre
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Doosan Babcock Energy Limited is a global, multi-specialist, energy services company.

- Doosan Babcock Energy:
  - Designs, supplies and constructs some of the cleanest, most efficient coal-fired power plant in the world
  - Provides complete aftermarket solutions for life extension, efficiency improvement and emissions reduction of coal fired power plant
  - Is a leading engineering services provider operating in thermal power, nuclear, oil and gas, and petrochemical industries

- Over 5,000 experts, engineers and technologists, in 20 offices around the world.

- Through constant innovation, we aim to provide the highest standards in cutting-edge science, new technologies and ground-breaking engineering solutions.
Doosan Babcock R&D Centre - Technology Disciplines

R & D Centre for boilers and related technologies. Exploiting new and innovative technologies and supporting existing products for Doosan Babcock and Doosan Heavy global power business.

**Environment**
- Development of effective NO\textsubscript{x} and heavy metal emission reduction technologies
- Development of carbon capture technologies (PCC & Oxycoal\textsuperscript{TM})

**Boilers**
- Development of market leading, high performance products
- Advanced Supercritical Boilers
- POSIFLOW\textsuperscript{TM} vertical tube

**Materials & Fuels**
- Development and validation of materials for boiler pressure part components
- Analytical analysis of wide range of fuels, including coal and biomass

**CFD & Software and Tools**
- Use of commercial codes for isothermal and combustion modeling
- Continuous development of a wide range of in-house tools

**Asset Management**
- Development of component monitoring systems
- Advanced fault prediction methods
- New inspection methods and tools
- Techno-economic models for lifecycle optimisation
Doosan Babcock’s Oxyfuel Combustion Technology Roadmap

For over 15 years, we have been a leading player in the development of low carbon technology.

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OxyCoal 2 – Demonstration of an Oxyfuel Combustion System

The OxyCoal 2 collaborative project is led by Doosan Babcock and supported by the Department of Energy and Climate Change.
OxyCoal 2 – Demonstration of an Oxyfuel Combustion System

During Summer 2009, Doosan Babcock Energy has commenced its 40MW\textsubscript{t} OxyCoal™ demonstration, the world’s largest demonstration of an oxyfuel combustion system.
OxyCoal 2 – Demonstration of an Oxyfuel Combustion System

Testing a burner of the type and size applicable to new build and retrofit coal-fired boilers.

- Demonstrate operational envelope and performance of the OxyCoal™ burner
  - Flame stability
  - Flame Shape
  - Turndown
  - Start-up
  - Shutdown
  - Transition between air and oxyfuel firing
  - Furnace heat transfer characteristics
  - CO₂
  - NOₓ
  - Carbon in ash
OxyCoal 2 – Demonstration of an Oxyfuel Combustion System

Full-scale testing of the oxyfuel combustion process on Doosan Babcock’s 90MW<sub>t</sub> Clean Combustion Test Facility (CCTF).

• Start-Up / Light-Up
• Air Heavy Fuel Oil Firing
• Air Coal Firing
• Transition
• OxyCoal Firing
• Shutdown

• Heavy Fuel Oil
  – 3000 litres
• Kellingley Coal
  – up to 50 tonnes
• Liquid Oxygen
  – up to 100 tonnes
Halifax Fans: Primary FGR Fan

- VSD Control
- Power: 160 kW
OxyCoal 2 – Demonstration of an Oxyfuel Combustion System

Halifax Fans: Secondary FGR Fan

- VSD Control
- Power: 400 kW
OxyCoal 2 – Demonstration of an Oxyfuel Combustion System

Air Products: Oxygen Storage Plant

- Design: 40MWt for 8 hrs/day
- 3 off Liquid O₂ Storage Tanks
- Capacity: 50,000 litres each
- 8 off Ambient Vaporisers
- Design Pressure: 25 Barg
OxyCoal 2 – Demonstration of an Oxyfuel Combustion System

Air Products: Oxygen Flow Control Skid

- Design: 70MWt
- Primary FGR Injection
  - Design O₂ Conc. 21% v/v
- Secondary FGR Injection
  - Max O₂ Conc. 45% v/v
Davidson Clark: FGR Cooling System

- Dry Primary / Transport FGR
- Closed Loop system
- 2 off Cooling Columns (Primary / Transport)
- 1 off Dual Cell Watermiser GRP Cooling Towers
- 1 off 12,800 litres Condensate Tank
Fawcett Christie Hydraulics: Primary FGR Heater

- Heating medium: Superheated Steam
- 2 off banks of finned tubes
- Design Pressure: 15 Barg
- Target PFGR Temperature: 110°C
OxyCoal 2 – Demonstration of an Oxyfuel Combustion System

Heat Flux Probes

- 10 off IFRF Total Heat Flux Design
- Water Cooled
- Investigate difference between Air and Oxyfuel firing
OxyCoal 2 – Demonstration of an Oxyfuel Combustion System

Gas Measurement Instruments: Carbon Dioxide Detection System

- Active 80 multi channel gas monitoring system
- 6 off CO\textsubscript{2} sensors, 0.5m off the ground
- Visual and Audible alarm
- Alarm level 1: 0.5% v/v (LTEL for CO\textsubscript{2})
- Alarm level 1: 1.5% v/v (STEL for CO\textsubscript{2})
OxyCoal™ Burner Design

- Based on current low NO\textsubscript{x} air-fired burner technology
  - Compatible with existing plant for retrofit purposes
  - Exploits range of potential operating conditions for both Oxyfuel and air firing

- Uniform “simulated air” flue gas composition and design recycle rate based on the consideration of heat transfer aspects

- For Oxyfuel operation the volumetric flow rate and oxygen content of the primary gas is maintained as per air firing

- The overall stoichiometry is 1.2, and the flue gas recycle rate chosen to give an adiabatic equivalent to air operation
OxyCoal™ Combustion Modelling: Temperature

- Modelling of a full scale OxyCoal™ burner in air staged and single stage oxyfuel firing modes showed acceptable flame characteristics and emissions performance.

- A narrower, hotter flame with increased burnout was predicted for oxyfuel at 66% recycle; flame cools as recycle rate increases.
OxyCoal™ Combustion Modelling: Carbon Monoxide

- Local CO concentrations in the flame can be much higher under oxyfuel firing conditions, especially at lower recycle rates (lower volume of gas in furnace).
- Exit concentrations are broadly comparable with air firing.
Preliminary results

Air Firing

Oxyfuel Firing
OxyCoal™ Burner Testing

Preliminary results – wall heat flux

Oxyfuel has lower heat flux & less peaky distribution due to FGR dilution effect in flame

Similar FEGT and heat flux towards furnace exit

Axial Distance From Burner Inlet

Heat Flux
Doosan Babcock’s Oxyfuel Combustion Roadmap

Through our investment in R&D we continually look for innovative ways to create a low carbon future.

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Concluding Remarks

Doosan Babcock is developing the capability to provide competitive oxyfuel firing technology suitable for full plant application post-2010.

- Doosan Babcock has established a dedicated Carbon Capture Business Group to commercialise Carbon Capture technologies.

- We are undertaking front end engineering design (FEED) studies for utility clients’ Oxyfuel power plants.

- We aim to design, supply and construct an oxyfuel power plant of similar scale that will be operational by 2015, and a 1000MW\textsubscript{e} oxyfuel power plant by 2020.
Doosan Babcock is committed to delivering unique and advanced carbon capture solutions.

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