Doosan Babcock Energy

Oxyfuel Combustion Technology

Official Opening of the OxyCoal™ Clean Combustion Test Facility

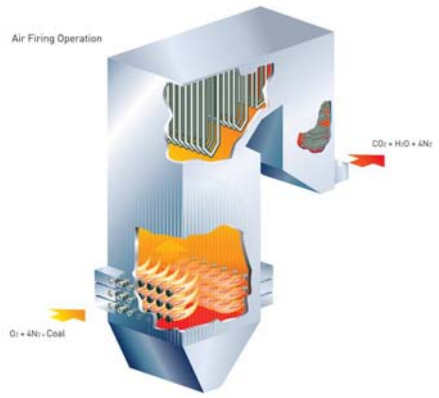
Technical Seminar

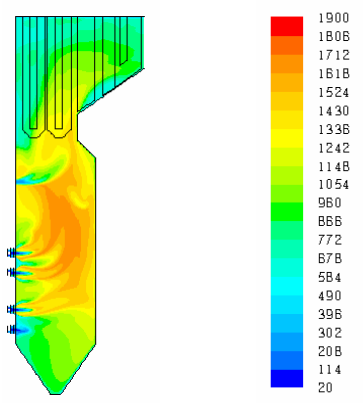
David Sturgeon
Date: 24 July 2009

Contents

Air Firing Technology

Pulverised fuel combustion under air firing operation produces a flue gas CO_2 concentration of typically 15%v/v dry basis.





Air Firing Furnace Temperature Profile

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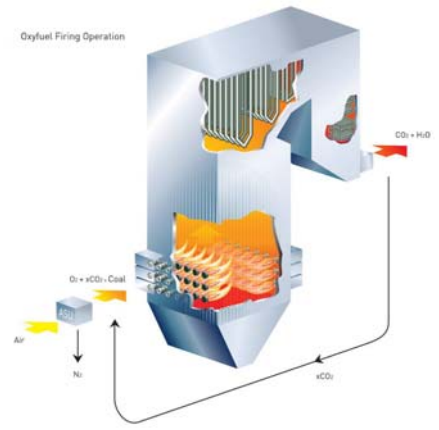
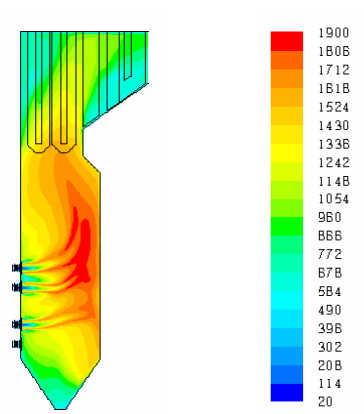
Oxyfuel Firing Technology

Pulverised fuel combustion under oxyfuel firing operation produces a flue gas CO_2 concentration of typically >75%v/v dry basis.





Oxyfuel Firing Furnace Temperature Profile

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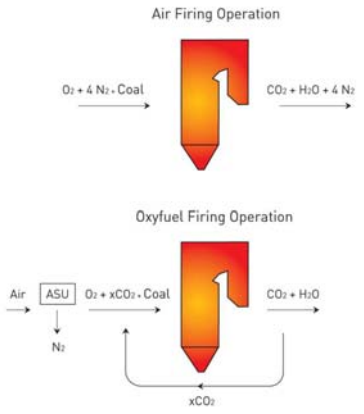
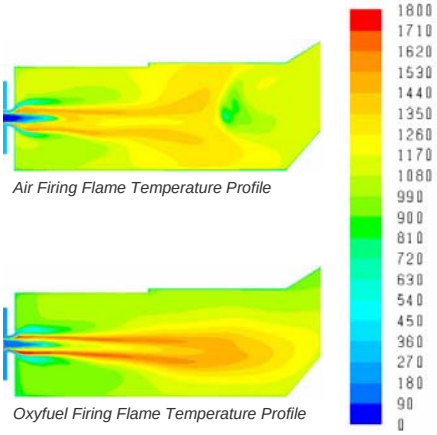
Air Firing Technology vs. Oxyfuel Firing Technology

Pulverised fuel combustion under oxyfuel firing operation produces a flue gas that requires minimal treatment prior to storage.





Air Firing Flame Temperature Profile

Oxyfuel Firing Flame Temperature Profile

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Doosan Babcock's Oxyfuel Combustion Technology Roadmap

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

1992 to 1995	2005 to 2008	2005 to 2008	2007 to 2009	2008 to 2010
• Pulverised Coal Combustion System for CO_2 Capture	• Oxy Combustion Processes for CO_2 Capture from Power Plant • Development and Experimental Validation of a Mathematical Modelling Methodology for Oxy-Fuel Combustion for CO_2 Capture in Large Power Plants	• CO_2 Capture Ready Power Plants • Enhanced Capture of CO_2 • Future CO_2 Capture Options for the Canadian Market • Coal-Fired Advanced Supercritical Retrofit with CO_2 Capture	• OxyCoal-UK: Phase 1 – Fundamentals and Underpinning Technologies	• OxyCoal-UK: Phase 2 – Demonstration of an Oxyfuel Combustion System

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OxyCoal-UK: Phase 1 – Fundamentals and Underpinning Technologies

The OxyCoal-UK: Phase 1 collaborative project addressed critical technology gaps and was led by Doosan Babcock and supported by the Technology Strategy Board.

University of Nottingham
Drop Tube Furnace

- Combustion Fundamentals
  - Characterisation of coal ignition, devolatilisation, char burnout and nitrogen partitioning behaviour under oxyfuel firing conditions.
  - Development of kinetic parameters from test data and application in CFD models of OxyCoal™ burner and oxyfuel boiler.
- Furnace Design and Operation
  - Investigation of the performance of the oxyfuel process and its key impacts on utility plant operation and performance.

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OxyCoal-UK: Phase 1 – Fundamentals and Underpinning Technologies

The OxyCoal-UK: Phase 1 collaborative project addressed critical technology gaps and was led by Doosan Babcock and supported by the Technology Strategy Board.

- Flue Gas Clean-Up
  - Development and testing of novel flue gas clean-up system for NO_X and SO_2 removal from oxyfuel derived flue gas.
- Generic Process Issues
  - A desktop study to investigate the key process issues associated with an oxyfuel installation on a large utility plant.

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Emissions Reduction Test Facility

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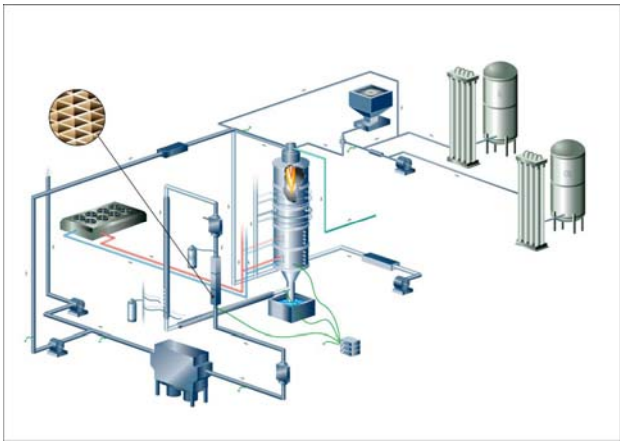
OxyCoal-UK: Phase 1 – Fundamentals and Underpinning Technologies

Pilot-scale testing of the oxyfuel combustion process on Doosan Babcock's 160kW$_t$ Emissions Reduction Test Facility (ERTF).



OxyCoal-UK: Phase 2 – Demonstration of an Oxyfuel Combustion System

The OxyCoal-UK: Phase 2 collaborative project is led by Doosan Babcock and supported by the Department of Energy and Climate Change.

Doosan Babcock Energy
Lead Company

Scottish and Southern Energy
Prime Sponsor

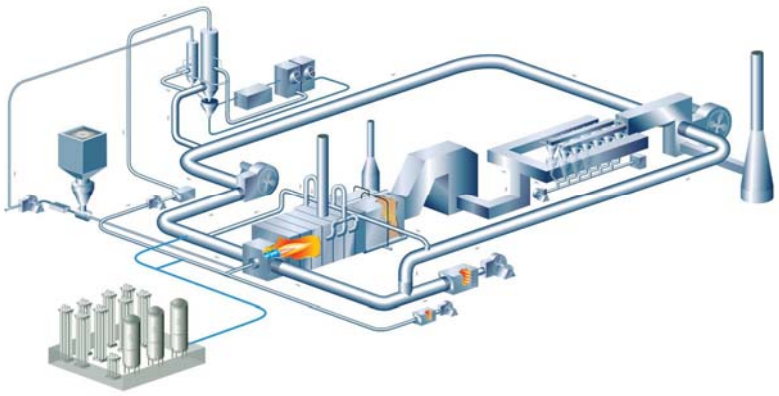
Imperial College London
The University of Nottingham
University Participants

DEPARTMENT OF ENERGY & CLIMATE CHANGE
UK Government Support

EDF ENERGY
AIR PRODUCTS
UK COAL
SCOTTISHPOWER
VATTENFALL
DONG energy
Drax Power Limited
e·on
Sponsors

OxyCoal-UK: Phase 2 – Demonstration of an Oxyfuel Combustion System

During Summer 2009, Doosan Babcock Energy has commenced its 40MW$_t$ OxyCoal™ demonstration, the world's largest demonstration of an oxyfuel combustion system.



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OxyCoal-UK: Phase 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 of the OxyCoal™ burner
  - Flame stability
  - Turndown
  - Start-up
  - Shutdown
  - Transition between air and oxyfuel firing

- Demonstrate successful performance of the OxyCoal™ burner
  - Flame stability
  - Flame shape
  - Furnace heat transfer characteristics
  - NO_x
  - Carbon in ash

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OxyCoal-UK: Phase 2 – Demonstration of an Oxyfuel Combustion System

Full-scale testing of the oxyfuel combustion process on Doosan Babcock's 90MW$_t$ 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

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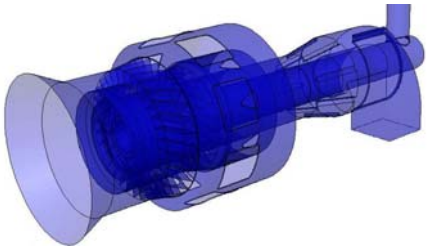
Optimised OxyCoal Combustion

The Optimised OxyCoal Combustion project is led by Doosan Babcock in collaboration with Air Products and is supported by the Technology Strategy Board.

- Investigate advanced oxyfuel burner concepts, using mathematical modelling, to exploit the potential of the oxyfuel process (efficiency, fuel flexibility).
- Define burner designs suitable for full scale testing and commercial exploitation.



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Impact of High Concentrations of SO_2 and SO_3 in Carbon Capture Applications and Mitigation

The $OxySO_X$ collaborative project is led by Doosan Babcock and supported by the Technology Strategy Board.

- Establish the impact of oxyfuel firing on SO_2/SO_3 and mercury behaviour.
- Determine the performance of in-furnace and post-combustion SO_3 sorbent injection under air firing and oxyfuel firing conditions.
- Establish a predictive capability for SO_3 sorbent injection and mercury behaviour in oxyfuel firing conditions.
- Determine the impact of oxyfuel firing conditions on fireside corrosion and low temperature corrosion.

E.ON Combustion Test Facility

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Doosan Babcock's Oxyfuel Combustion Roadmap

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

2008 to 2010	2008 to 2010	2009 to 2011	2009 to 2015	2020
• OxyCoal-UK: Phase 2 – Demonstration of an Oxyfuel Combustion System	• Optimisation of Oxyfuel PF Power Plant for Transient Behaviour • Optimised OxyCoal Combustion	• Impact of High Concentrations of SO_2 and SO_3 in Carbon Capture Applications and Mitigation	• Front End Engineering Design Studies • 100 to 250MW_e Oxyfuel Demonstration Power Plants	• 1000MW_e Oxyfuel Power Plant • Commercialisation
				

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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 a front end engineering design (FEED) study for a utility client for a 100MW_e oxyfuel power plant.
- We aim to design, supply and construct an oxyfuel power plant of similar scale that will be operational by 2015, and a 1000MW_e oxyfuel power plant by 2020.

Commercial Contact Details

Doosan Babcock is committed to delivering unique and advanced carbon capture solutions.

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