

# Profiles

July 2010  
PF 10-09

## Oxyfuel combustion of pulverised coal

'Oxyfuel combustion is one of the leading options for CO<sub>2</sub> capture'

Oxyfuel combustion is one of the leading options for power generation with CO<sub>2</sub> capture. It can be simply described as a process that eliminates nitrogen from the oxidant or comburent by burning the fuel in either nearly pure oxygen or a mixture of nearly pure oxygen and a CO<sub>2</sub> rich recycled flue gas (RFG) resulting in a product flue gas from the boiler containing mainly carbon dioxide and water vapour. Burning of fuel with pure or nearly

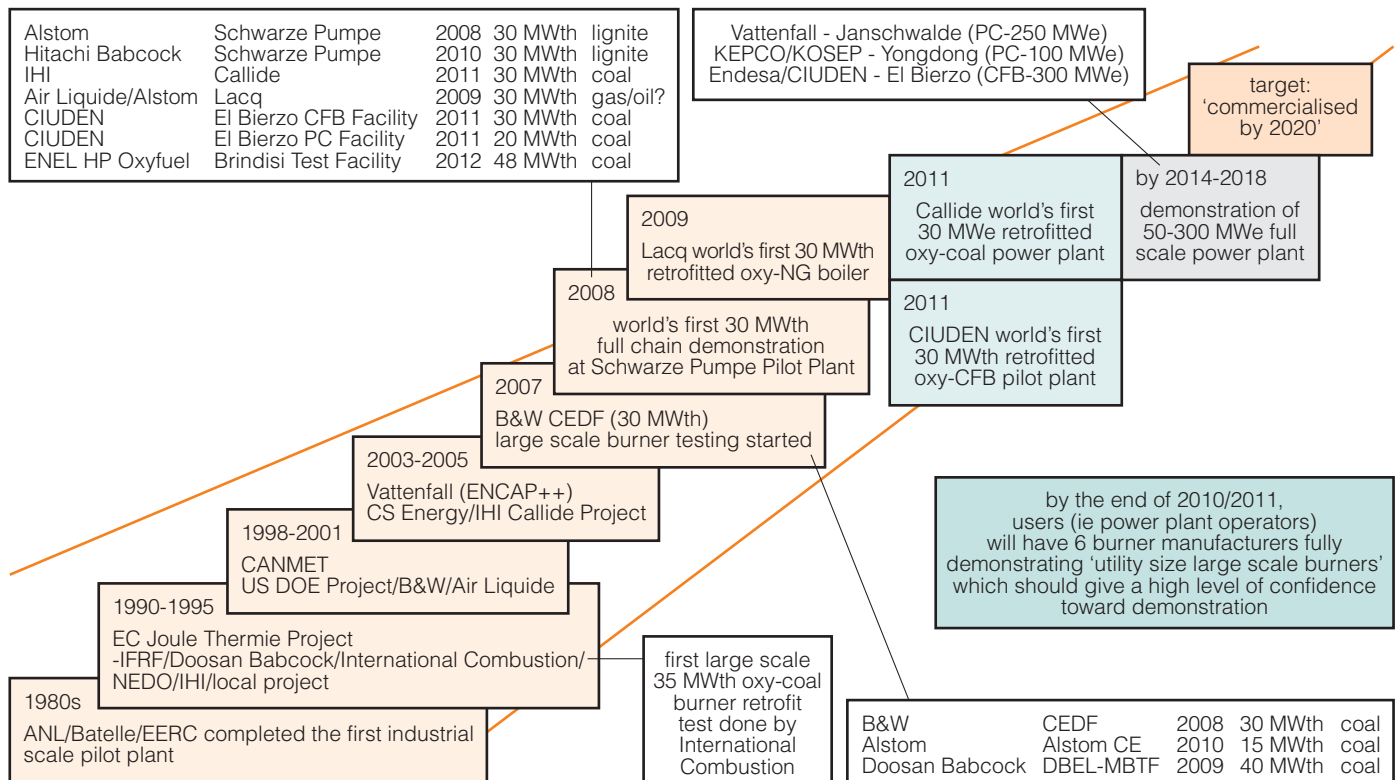
'There are concerns about the effects of sulphur in coal'

pure oxygen is typically applied to high temperature processes such as reheating furnaces or glass tank furnaces; whereas for steam generation applications such as pulverised coal boilers, lower combustion temperatures are necessary. Therefore, fuels are burned with a mixture of CO<sub>2</sub> rich recycled flue gas or steam (to act as diluents replacing nitrogen in order to moderate the temperature) in addition to the oxygen from an air separation

'The process is technically viable'

unit. In the current design of the oxyfuel combustion for pulverised coal fired boilers, the CO<sub>2</sub> rich recycled flue gas is used as the diluent.

The combustion products (or flue gas) consist mainly of carbon dioxide and water vapour together with excess oxygen required to ensure complete combustion of the fuel. The net flue gas after condensing all the water vapour can typically contain about 80–95% (db) CO<sub>2</sub> for any coal fired oxyfuel



boiler depending on coal type, excess oxygen, air in-leakage and flue gas processing employed. This concentrated CO<sub>2</sub> rich flue gas from the boiler is further purified, dried and compressed before delivery into a pipeline for storage.

Oxyfuel firing affects the combustion of pulverised coal. It is generally agreed that ignition is retarded but that this can be countered by increasing the oxygen content of the comburent gases. There can also be a lower flame propagation velocity due to the higher specific heat of CO<sub>2</sub> compared with N<sub>2</sub>. The effects on burnout are less clear cut – in general, it has been found that burnout is lower in oxyfuel conditions but, again, this can be remedied by increasing the amount of oxygen. However, there is evidence that burnout may be enhanced for lower reactivity coals. There is evidence for char-CO<sub>2</sub> gasification reactions that may also be coal dependent but it is also difficult to assess how important these reactions are. Heat transfer has been found to be influenced by the flue gas recycle ratio (R); the effect of increasing R is to decrease the heat transfer efficiency.

The SO<sub>2</sub> concentration in the oxyfuel flue gas is two to five times higher in the oxyfuel flue gas than in the air fired flue. However, in terms of specific mass per energy input the SO<sub>2</sub> emissions in oxyfuel combustion are about 30–40% lower than in air fired combustion. This lower emission is attributed to retention of sulphur in the ash primarily due to its high temperature direct sulphation and the inhibition of decomposition of calcium sulphate at high temperatures. However, it has been suggested that additional sulphur capture in ash could be promoted by increased formation of SO<sub>3</sub> and subsequent deposition. Although difficult to measure, it appears that the SO<sub>3</sub> concentration (in ppm) is higher in oxyfuel combustion than in air combustion.

The reduction in nitrogen oxides (NO<sub>x</sub>) formation has been an important driver for research into oxyfuel combustion. NO<sub>x</sub> emissions are lower in oxyfuel conditions compared with air fired emissions and much, if not most, of this reduction can be attributed to the effects of the flue gas recirculation.

Studies on the impact of the modified combustion environment on ash slagging and fouling and associated effects such as tube corrosion are still at

relatively early stages but there are concerns about the effects of sulphur in coal. In oxyfuel combustion, the higher SO<sub>2</sub> and H<sub>2</sub>O concentrations resulting from recycled flue gas and lower gas volumes are expected to produce a higher concentration of SO<sub>3</sub> and hence a higher acid dew point. For coals with both high sulphur and high chlorine there is potential for a severe increase in corrosion especially for high chromium content alloys.

Recently, considerable progress has been made in the development of oxyfuel technology:

- the process is technically viable;
- the process is reasonably well understood;
- the process has been demonstrated at pilot scale;
- the process is being demonstrated at large scale (30 MWth +);
- most of the individual components are in commercial operation at the required scale.

However, some commentators believe that there is a perception that post-combustion carbon dioxide capture is 'easier'. Nevertheless, several utilities are making or planning significant investments in oxyfuel technology with large scale testing and plant demonstration. It is likely that market, economic, public acceptability and legal issues are more significant than technical issues as barriers to the commercial deployment of oxyfuel technology.

Each issue of *Profiles* is based on a detailed study undertaken by IEA Clean Coal Centre, the full report of which is available separately. This particular issue of *Profiles* is based on the report:

### **Oxyfuel combustion of pulverised coal**

Robert Davidson, Stanley Santos  
CCC/168, ISBN 978-92-9029-488-7,  
63 pp, June 2010,  
£255\*/£85†/£42.50‡

- \* non-member countries
- † member countries
- ‡ educational establishments within member countries

IEA Clean Coal Centre is a collaborative project of member countries of the International Energy Agency (IEA) to provide information about and analysis of coal technology, supply and use.

IEA Clean Coal Centre has contracting parties and sponsors from: Australia, Austria, Brazil, Canada, China, Denmark, the European Commission, Germany, India, Italy, Japan, Republic of South Korea, the Netherlands, New Zealand, Poland, Russia, South Africa, Sweden, Spain, Thailand, the UK and the USA.



Gemini House  
10-18 Putney Hill  
London SW15 6AA  
United Kingdom

Tel: +44 (0)20 8780 2111  
Fax: +44 (0)20 8780 1746  
e-mail: [mail@iea-coal.org](mailto:mail@iea-coal.org)  
> Internet: [www.iea-coal.org](http://www.iea-coal.org)