Clean Coal Technology Towards Green Power Generation

By: *Engr. Fam Yew Hin,* *MIEM, P.Eng*

Power generation using coal has long been perceived as the most environmentally polluting source of energy. In fact, until today, the debate on using coal as fuel is still being polarised by simplistic views about global warming. But do all these perceptions still hold true?

Over the past decade, coal generation technology has essentially undergone an extensive revolution and tremendous changes. Today, coal-fired electricity is taking on a new green aura thanks to various Clean Coal Technologies (CCTs) that enable this abundant fuel to be used more cleanly than ever before. These CCTs are a variety of evolving responses to environmental concerns, including that of global warming due to the release of carbon dioxide (CO_2) into the atmosphere.

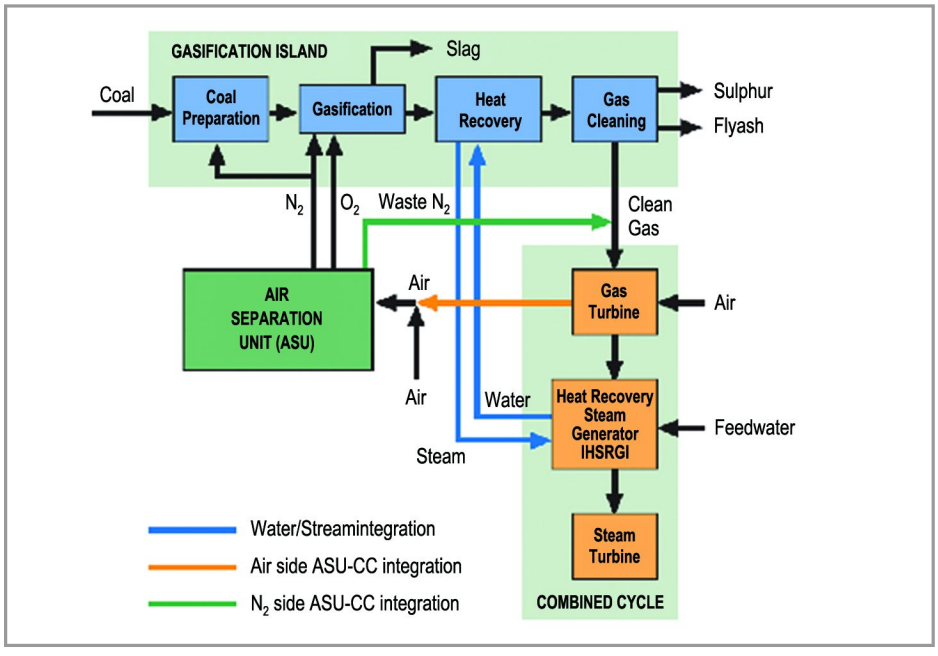
Amongst others, the various CCTs that are being used to address environmental issues are:

- Coal cleaning by 'washing', a coal preparation process commonly conducted to remove unwanted minerals by mixing crushed coal with a liquid, and allowing the impurities to separate and settle. Coal cleaning can effectively reduce the emission of ash and sulphur dioxide when the coal is burned in a boiler.
- Electrostatic Precipitator (ESP) or electrostatic air cleaner, a particulate collection device that could remove up to 99% of fly ash from the flue gases by using the force of an induced electrostatic charge.
- Flue gas desulphurisation (FGD), a post-combustion sulphur control process where flue gases are scrubbed with chemical absorbent or seawater to remove and reduce the output of sulphur dioxide into the atmosphere.
- Low NOx burners that control the way coal and air mixes at each burner in order to reduce the maximum flame temperature and hence, nitrogen oxide emission. The effectiveness of low NOx burners could be further enhanced if it is coupled with re-burning techniques and with selective catalytic reduction.
- Advanced technologies such as the Integrated Gasification Combined Cycle (IGCC) and Pressurised Fluidised Bed Combustion (PFBC) that enable higher thermal efficiencies. The IGCC plant is a means of using coal and steam to produce hydrogen and carbon monoxide which are then burned in a gas turbine with secondary steam turbine (i.e. combined cycle) to produce electricity. Currently, IGCC plants have an approximately 45% thermal efficiency.

The remainder of this article aims to introduce the concept of IGCC power plants as the author believes in the potential of IGCC technology, which is expected to be predominantly used in the future of the power generation industry.

An IGCC power plant is a power generation plant using synthetic gas (Syngas) as the fuel. The plant is 'integrated' because the Syngas is produced in a gasification unit in the plant, optimised for the plant's combined cycle units. A schematic flow diagram of an IGCC plant is shown:

1. Coal, water and oxygen (produced from the air separation unit) are fed into a high-pressure gasifier, where the coal is partially combusted and converted into Syngas.
2. The ash from the coal is converted into an inert glassy slag.
3. The Syngas produced in the gasifier is cooled and cleaned [The hot steam produced from the cooling process is channelled to the Heat Recovery Generator (HRSG)].
4. The sulphur is removed from the Syngas and is converted into either elemental sulphur or sulphuric acid for sale to chemical companies or fertiliser companies.
5. The fly ash collected may be used to produce cement or other products.
6. The Syngas is then fired in a gas turbine.
7. The hot exhaust from the gas turbine passes through the HRSG and produces high temperature steam,



(To be continued at page 16)

which, in turn, drives a steam turbine.

8. Electricity is produced from the generators coupled to both the gas and steam turbine.

BENEFITS OF IGCC PLANTS

The integration of a gasification plant with a combined cycle power plant is the most efficient method currently available to convert solid fuel into electricity. An IGCC plant consumes less fuel (per MW) than a large scale standard coal fired power plant. Besides, IGCC plants consume less water than a typical modern coal fired power plant.

The use of gas turbines (which utilises the Syngas) effectively reduces water consumption as compared to a typical coal fired thermal plant of similar size (where water is used as the working medium throughout). IGCC plants are also considerably smaller in physical size and footprint than a standard coal fired power plant. The buildings are much smaller, with the outside facilities consisting mostly of vessels and pipes.

Finally, IGCC plants have minimal need for landfills. The ash in the feedstock is saleable, especially to cement producers. The sulphur is captured as elemental sulphur and sold to the fertiliser industry for agricultural use. This lack of waste products greatly reduces the burden on the local landfill and transportation requirement.

IGCC plants have an additional advantage in comparison to traditional combustion technology. IGCC plants can be designed in such a way that CO^2 is removed prior to the Syngas being fed to gas turbines. This 'greenhouse' gas is of great concern as many scientists believe it has contributed to global warming. In a traditional power plant, the removal of this 'greenhouse' gas can only be done after combustion, which is not economically feasible.

Notwithstanding the benefits above, the high cost of IGCC has become the biggest obstacle to its integration in the power sector. However, with the current plateauing of oil prices and depleting oil reserves, coal is definitely one of the main alternative fuel in power generation. ■

SMART QUOTES

"The best hope of raising our own standards lies in the progressive expansion of production both here and abroad and making sure that the gains of increased productivity are, in fact, applied to social advance."

-Carter Goodrich

(Source: The Forbes Book of Business Quotation, Black Dog and Leventhal Publishers Inc.)