Overview of CO_2 Reduction by IGCC Technology

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Coal is an important source of energy, accounting for about 25% of the world's primary energy and about 20% of Japan's. Yet the CO_2 emission per heating value from coal is quite large. An important challenge, for the continued use of coal, has been to reduce CO_2 emission by enhancing efficiency. Studies have recently been conducted on CCS (carbon capture and sequestration) in order to reduce CO_2 emission further. The Integrated coal Gasification Combined Cycle (IGCC) has been attracting attention as the most efficient and economic coal firing thermal power generation technology for capturing CO_2. This paper reports on the forefront trends in IGCC and CO_2 capture.

1. IGCC development

Integrated coal Gasification Combined Cycle (IGCC) is a power plant system designed to run more efficiently than conventional coal firing systems by combining coal gasification with a gas turbine combined-cycle power plant.

Nine electric power companies in our country have been working with Electric Power Development Co., Ltd. and Central Research Institute of Electric Power Industry (CRIEPI) to develop a more efficient and highly reliable air-blown IGCC, with subsidy funding from the national government. From 1986 to 1996, the collaborators built and operated a pilot plant test on the scale of 200 t/day (corresponding to 25 MW) in a project entrusted by the Agency for Natural Resources and Energy and the New Energy and Industrial Technology Development Organization (NEDO). And from the beginning of this decade, Clean Coal Power R&D Co., Ltd. (established in June 2001) has been moving forward with the test operation of a 250 MW-class IGCC demonstration plant (hereinafter "IGCC demonstration plant").

The gas turbine of the IGCC demonstration plant was ignited in May 2007, and the gasifier was ignited four months later, in September. Tests are scheduled to continue until 2010.

2. Plan for IGCC commercial plant

2.1 Plan for IGCC commercial plant in the United States

Power producers in the United States are carrying forward many plans for coal firing power plants to make effective use of abundant domestic energy resources, and to reduce their reliance on natural gas (an increasingly expensive resource). The improved environmental performance of IGCC is especially attractive to them.

With encouragement from Incentive Tax Credit (ITC) in the Energy Policy Act enforced in August 2005, some IGCC projects targeting commercial operation in the 2010s are being studied. The adoption of ITC in three IGCC projects was announced in December 2006, and plans for more projects are scheduled to be announced in April 2008.

Electric Power companies are actively pursuing business projects for commercial plants. AEP (American Electric Power), for example, applied for an IGCC of the 600 MW class with the Public Utilities Commission in West Virginia in June 2007. Duke Energy, meanwhile, adopted an IGCC of the 600 MW class for ITC.

On the other hand, studies on the FEED (Front End Engineering and Design: Detailed design for project cost estimation) of these projects have shown that all rely on slurry-feed oxygen-blown gasifiers based on technologies from other companies. The projects thus have low net plant power efficiency (38.6%) (under HHV base), with CCS (carbon capture and sequestration) positioned as a future installation plan. The power plants clearly need to elaborate their plans and discussions for efficiency enhancement and improved environmental performance.

2.2 Plan for air-blown IGCC commercial plant

To meet the market need for vitalized business projects for commercial plants, efficiency enhancement, and improved environmental performance, Mitsubishi Heavy Industries, Ltd. (MHI) has started a study on a highly efficient IGCC commercial plant adopting a 1500°C class gas turbine. **Figure 1** shows the external appearance of an air-blown IGCC commercial plant. **Table 1** shows a comparison of the main specification data between the IGCC demonstration plant and a commercial plant. The gasifier in the commercial

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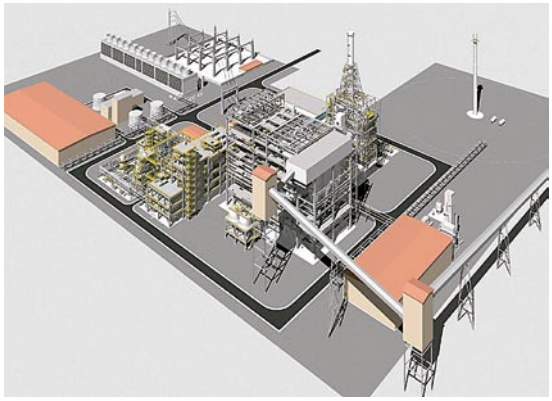

Fig. 1 External appearance of an air-blown IGCC commercial plant

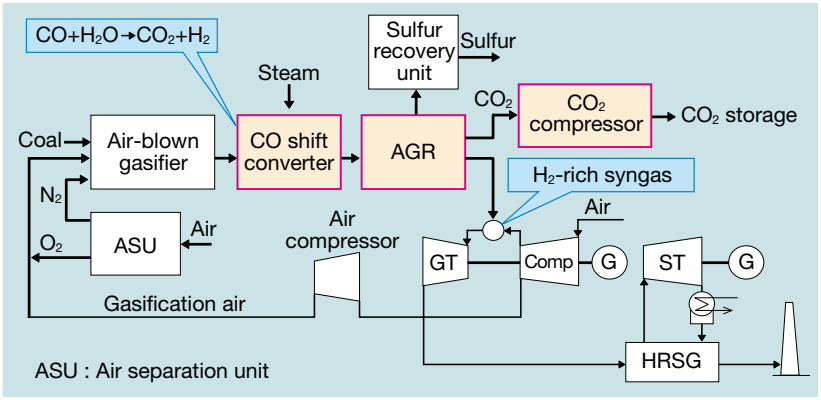

Fig. 2 Block flow diagram of the air-blown IGCC system with CO_2 capture

Table 1 Comparisons of main specification data between IGCC demonstration plant and commercial plant

Item			Demonstration plant	Commercial plant
Gross power output		(MW)	250	500 (60 Hz)
Type of coal		(–)	Bituminous coal	Bituminous coal
Gasifier		(–)	Dry feed Air blown	Dry feed Air blown
Gas cleanup system		(–)	Wet desulfurization	Wet desulfurization
Gas turbine		(–)	M701DA	M501G
Net power plant efficiency		(%, HHV)	40.5	46
Environmental Targets (16% O_2 basis)	SOx	(ppm)	8	8
	NOx	(ppm)	5	5
	Particulate matter	(mg/m^3_N)	4	4
Start of operation		(–)	2007	Earliest : 2012

plant has an assumed scale-up to twice the capacity ratio of the IGCC demonstration plant. The gas turbine will adopt a combustor capable of firing syngas at high efficiency, based on many of the techniques MHI has used to achieve outstanding performance with its low-calorie firing gas turbines. The IGCC commercial plants incorporating MHI's latest gas turbines can reduce CO_2 per kilowatt-hour by about 15% compared with conventional coal firing plants, because of the improved net plant efficiency.

MHI also studies the use of PRB (Powder River Basin) coal, an inexpensive coal found in abundance in the United States, for IGCC commercial plants. While the slurry feed system cannot easily adopt PRB coal because of the high water content (20 to 30 wt%), MHI's dry feed system can generate electric power with high efficiency using this coal.

3. CO_2 capture by IGCC

Countries all over the world are studying IGCC systems with CO_2 capture, to address the crisis of global warming. Generally there are two methods to capture CO_2 for the coal firing power plant: (1) a method to capture CO_2 from boiler flue gas; (2) a method to capture CO_2 from syngas before combustion.

Because IGCC can capture CO_2 from syngas under pressurized condition, the treated gas volume is small and the CO_2 concentration is high. Compared with CO_2 capture from boiler flue gas, the capture of CO_2 from syngas requires only a small loss of plant efficiency and only a modest increase in power generation cost.

Figure 2 shows block flow diagram of the air-blown IGCC system with CO_2 capture. Carbon monoxide (CO) in syngas produced in gasifier is converted, along with water, into CO_2 and hydrogen (H_2) in a CO shift converter. CO_2 is separated and captured from syngas in the AGR (Acid Gas Removal: Gas cleanup including desulfurization / CO_2 capture). The H_2-rich syngas from which the CO_2 has been removed is used as fuel in the gas turbine. In the IGCC with CO_2 capture, the CO shift converter and CO_2 capture system must be optimized according to the required rate of CO_2 capture.

Figure 3 shows the comparisons of capital cost and net power output between an air-blown IGCC and oxygen-blown IGCC during CO_2 capture.

Though the air-blown gasification produces much more

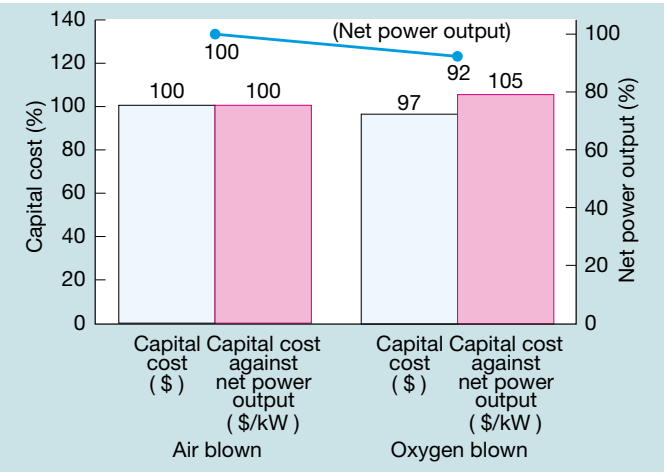

Fig. 3 Comparisons of capital cost and net power output between the air-blown IGCC and oxygen-blown IGCC during CO_2 capture

raw syngas than oxygen-blown gasification on a volume basis, the gasifier and AGR in the air-blow gasification IGCC system have only a small influence on capital cost. On the other hand, the net power output in air-blown gasification is larger. Thus, air-blown gasification has advantages in terms of capital cost ($/kW).

4. Conclusion

IGCC is a core technology used in the next-generation of coal firing power plants. Our company is conducting various demonstration tests using a 250 MW class IGCC demonstration plant to confirm the reliability and safety. We are also acquiring lesson-learnt data from a demonstration plant that can reflect to commercial plant design and establish an air-blown IGCC system with high efficiency and high reliability.

Ultimately, we will realize IGCC commercial plants with the additional capability of CCS, to respond to environmental requirements. While CCS has the potential to substantially reduce CO_2 emissions, there are several challenges posed by declines in efficiency, higher capital costs, and variation in the geological potential to store CO_2 in the regions where plants are built. We therefore intend to study not only the power generation equipment, but total system configuration as well.


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