5A4. Oxy-fuel Combustion (Oxygen-firing of Conventional PCF System)

Research and development: Japan Coal Energy Center; J-POWER; Ishikawajima-Harima Heavy Industries, Co., Ltd.; Taiyo Nippon Sanso Corporation (Nippon Sanso Corp.); and Institute of Research and Innovation
Project type: Coal Production and Utilization Technology Promotion Grant
Period: 1992-2000 (8 years), 2004-2005 (2 years)

Technology overview

1. Background and the oxy-fuel combustion system

The Kyoto Protocol entered into force in February 2005, and now many countries are working actively toward the second commitment period starting in 2013. From a global viewpoint, however, thermal power plants are releasing CO_2 in large quantities, which indicates the necessity for a power generation system with CO_2 recovery and storage capabilities. Among all the fossil fuels used at thermal power plants, coal produces the greatest amount of CO_2 per calorific unit value.

In the process of recovering CO_2 through oxy-fuel combustion as shown in Figure 1, O_2 is separated from combustion air and used for burning coal. In this process, it is theoretically possible to improve the CO_2 concentration in the emissions to 90% or more, and to easily recover CO_2.(1) When this technology is applied to power plants for the purpose of controlling the flame temperature, flue gas (mostly CO_2) is recirculated and mixed with O_2. With this technology, it has been confirmed that the process characteristics help reduce NOx emissions. Expectations for this system are high because it represents a direct CO_2 recovery method that is better than other CO_2 recovery systems in terms of economical efficiency and technological feasibility.

In the future, it will be increasingly necessary to establish a coal-fired power plant with CCS (Carbon Dioxide Capture and Storage). In this respect, it will be important to integrate the power generating unit and the CO_2 recovery and storage capabilities.

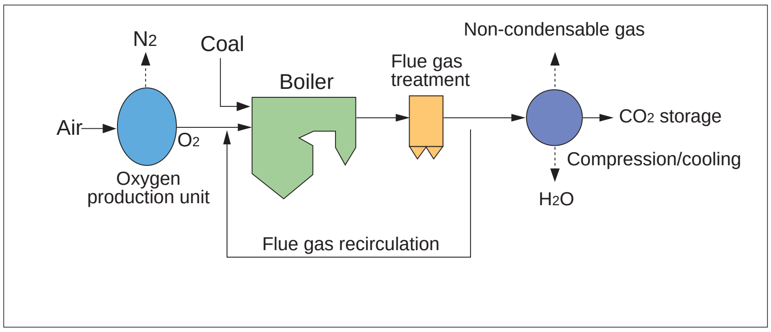

Fig. 1 Concept of oxy-fuel combustion with CCS

2. Development results

An application study on an existing 1000MWe coal-fired power plant was carried out to examine the system structure and the boiler furnace, as well as the operating and economic efficiency.

Table 1 and Figure 2 show the specifications of the existing 1,000 MWe power plant when the oxy-fuel combustion system was introduced. In applying oxy-fuel combustion, motive power is necessary for oxygen production and CO_2 recovery. The station service power occupies up to 30% of the total electricity generated, and the net efficiency is 30%. The amount of CO_2 recovered is about 800 t/hr (or about 5 million tons per year.)

According to our calculation, the cost for CO_2 separation and recovery is approximately 3,000 yen per ton-CO_2. In this process, the initial cost and the operational and maintenance costs for oxygen production account for more than half of the total cost, and thus it is hoped that innovative oxygen production technology will be developed.

Table 1 Specifications of a plant with oxy-fuel combustion system

Specifications	Unit	Air combustion	Oxy-fuel combustion
Rated output	MWe	1050	1050
Net efficiency	%	40	30
Station service power	%	5	30
Availability	%	80	80
Coal consumption (Australian coal)	t/h	330	330
Oxygen supply	km^3N/h	480 (in Air)	430
CO_2 recovery rate	%	–	95
CO_2 recovery	t/hr	–	802

3. Demonstration project in Australia

On the basis of the study results described above, demonstrative studies are now underway for applying oxy-fuel combustion to an existing plant.[4] These studies include an Australia-Japan joint project in which an oxy-fuel combustion demonstration plant will be completed by the end of 2008. This project aims to recover and store CO_2 from an existing power plant. The outline of the project is as follows:

The project is being implemented at a power generation plant in the Callide-A power plant's No. 4 unit owned by CS Energy on the east coast of Australia. This unit was selected because it has adequate capacity as a demonstration plant. Additionally, it is currently out of service and thus is available for modifications.

The storage site is planned to be located in a depleted gas field, about 250 km to the west of the power plant. This site was chosen because it is not far away from the power plant, the estimated CO_2 storage capacity is sufficient, and the reservoir characteristics such as permeability and porosity are adequate.

The entire project schedule is shown in Table 2. For this demonstration project, Australia and Japan jointly conducted a feasibility study from FY2004 to FY2005. Based on its results, detailed studies began in 2006, aiming at completing the plant by the end of 2008. Demonstrative operation of the oxy-fuel combustion system will be carried out for five years after completion. Storage of captured CO_2 will start in FY2011, and thus demonstration and monitoring of CO_2 storage will be carried out for three years.

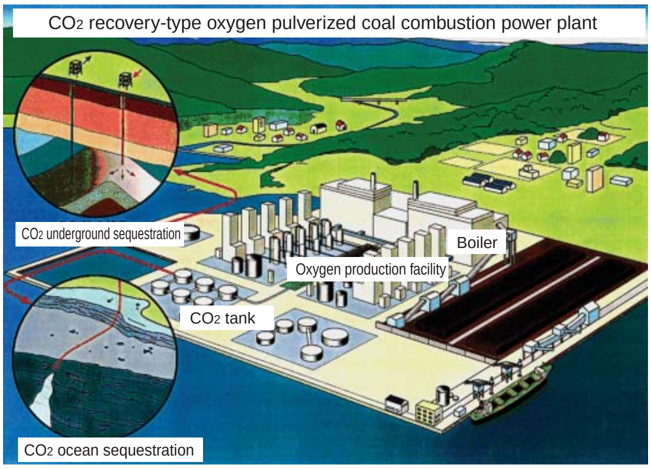

Fig. 2 Image of CO_2 recovery-type power plant applying oxygen combust

Table 4 Project schedule

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Feasibility sudy			FS									
Boiler modification & demonstration of CO_2 recovery	Design, construction, commissioning						Demonstrative operation					
Demonstration of CO_2 storage		Test drilling, design, construction, commissioning						CO_2 storage & monitoring				
Summary												

4. Issues and feasibility of practical application

As described above, the demonstration of a power plant using oxy-fuel combustion is now about to start. Hopefully by the year 2010, it will be demonstrated that the system is reliable and economically efficient for CO_2 recovery. It is necessary first and foremost to ensure the steady implementation of the Australia-Japan demonstration project, so that it will be the first step toward commercialization. The following topics will be the subjects of the demonstration and further studies:

(1) Stability and safety in the operation of a power plant using oxy-fuel combustion

(2) Stable operation of a CO_2 recovery system

(3) Efforts for reducing costs and enhancing efficiency

(4) Total system optimization for power generation and CO_2 recovery/transportation/storage

References

1) K. Kimura et al., JSME-ASME Int. Conf. On Power Eng.-93, Tokyo, Sept. 1993.
2) NEDO, "Report on the Clean Coal Technology Promotion Project 2004: Study on the Application of Oxygen Combustion Technology to an Existent Pulverized Coal-Fired Power Plant".
3) NEDO, "Report on the Clean Coal Technology Promotion Project 2005: Study on the Application of Oxygen Combustion Technology to an Existent Pulverized Coal-Fired Power Plant".
4) C. Spero, Proc. Clean Coal Day in Japan 2004, Advanced Clean Coal Tech. Int. Symp. Tokyo, Sept. 2004.