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Application and demonstration of Oxyfuel combustion technologies to the existing power plant in Australia

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Abstract

Oxyfuel combustion is able to directly make the highly concentated CO_2 from the flue gas of pulverized coal fired power plant and, therefore, is expected as one of the promising technologies for CO_2 capture. We are advancing the Oxyfuel combustion demonstration project, which is called Callide Oxyfuel Project, with the support of both Australian and Japanese governments. Currently the boiler retrofit work is completed and the commissioning in Air combustion is going on. In this paper, we introduce the general outline of the Callide Oxyfuel Project and its progress.

Keywords: Coal Combustion, CO_2, Oxyfuel, Power Plant, CCS

1. Preface

Oxyfuel combustion is able to directly make the highly concentated CO_2 from the flue gas of pulverized coal fired power plant and is expected as one of the promising technologies for CO_2 capture. Therefore the development of this technology is advanced toward the commercialization around the year 2020 in the world.

We have been studying the Oxyfuel combustion in Japan from the 1990s. Those studies are including, for example, basic combustion characteristics test by drop tube furnace, combustion test by Oxyfuel pilot test fascility in our Aioi works and furnace combustion simulation and so on.

2. Features of Oxyfuel

Oxyfuel combustion is the combustion method that makes the highly concentrated CO_2 by burning the coal with the mixed gas between the oxygen from ASU and the recycled flue gas (RFG) instead of air. The amount and composition of the flue gas in both methods are shown in Figure 1. As shown in Figure 1, the amount of flue gas of Oxyfuel combustion is about one-fifith of that of Air combustion and the major composition changes from N_2 at Air combustion to CO_2 .at Oxyfuel combustion Therefore Oxyfuel combustion has the merit not only that it is easy to capture CO_2 from the flue gas, but also that the energy consumption of the boiler and auxiliaries can decrease due to less amount of the flue gas.

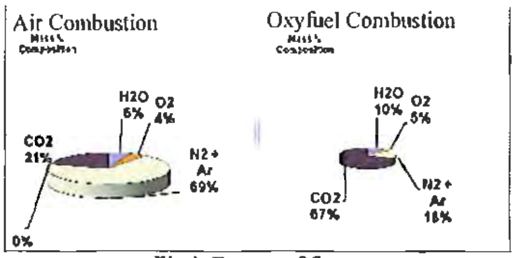

Fig.1: Feature of flue gas

Oxyfuel combustion has other merits as follows.
- Air pollutants such as NOx, SOx, particulates and so on can be reduced.
- The Oxyfuel technology can be applied to both brand-new power plant and retrofit of existing power plant.

3. Outline of Callide Oxyfuel Project

We, Japanese participants and Australian participants, joined together by starting to study the feasibility of Oxyfuel combustion technology on the basis of the results of the

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previous tests in 2004 and to study applying this technology to the existing power plant in detail in 2006. As a result of these studies, we commenced the demonstration project in 2008, which is called "Callide Oxyfuel Project" under the support of both Australian and Japanese governments.

The project involves 3 stages as follows; Stage 1 is Boiler retrofit and CO_2 capture; Stage 2 is CO_2 road transport & geological storage; Stage 3 is project conclusion. The total demonstraion period is scheduled to be about 7 years.

The project has three broad goals, namely to:

(1) Demonstrate a complete and integrated process of Oxyfuel combustion of pulverised coal within a National Electricity Market facility, incorporating oxygen production, Oxyfuel combustion, CO_2 processing and liquefaction, and CO_2 transport and geological storage;

(2) Obtain detailed engineering design and costing data and operational experience to underpin the commercial development and deployment of new and retrofit Oxyfuel boiler applications for electricity generation; and

(3) Obtain detailed geotechnical design and costing data and operational experience to support the development of geological storage projects of CO_2.

The plant used is Callide A power station unit 4 which is located at about 500km north of Brisbane in Queensland, Australia as shown in Figure 2.

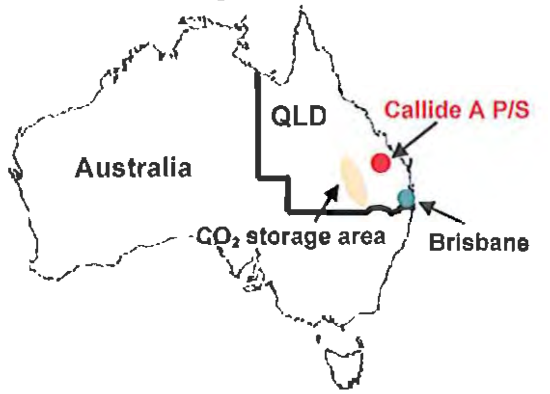

Fig.2: Location of Callide A Power Station and Storage area

Boiler and auxilialies are retrofitted for the Oxyfuel combustion. The existing equipment is reused about the steam turbine and auxilialies. Air separation unit (ASU) of 2x 330 tpd and CO_2 compression and purification unit (CPU) of 70 tpd are newly installed. The tanker lorry is used for CO_2 transportation to storage site. And we are now studying the sites of aquifers as the candidate of storage site. The major conditions of retrofitted power plant are shown in the Table 1.

Table 1: Major condition of the retrofitted power plant

Power plant	Callide A P/S unit 4
Output	30MW
Steam condition	136 tph at 4.1MPa, 465degC
First commissioned	1966-1968
Refurbished	1997-1998
Placed into dry storage	2002

Oxyfuel process in the Callide Oxyfuel Project is shown in Figure 3.

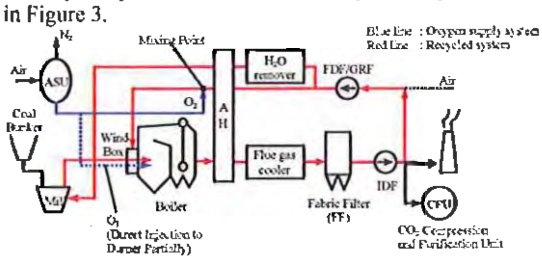

Fig.3: Combustion system flow on Callide Oxyfuel Project

In this project, the oxygen produced with ASU is supplied to the boiler at the two points. One is main oxygen and supplied at the point between AH outlet and Windbox inlet. Another is supplementary oxygen for the support of combustion and supplied directly to the furnace. We paid special attention to the oxygen mixing device to ensure that the oxygen mix with RFG sufficiently. We can control the flame temperature and the heat duty in the furnace by changing the amount of the RFG mixed with oxygen.

The two existing burners out of six are exchanged for IHI-low-NOx-burner to ensure that we check the effect of the difference of burner and the remaining existing burners are modified partly to be able to inject the oxygen into the furnace directly.

The pressure parts of the boiler do not need to be retrofitted.

CO_2 rich flue gas is devided into three streams at IDF outlet, first one is to be the liquified CO_2 after compression and purification with CPU, next one is used as the RFG through FDF/GRF and the last one is emitted into the atmosphere through stack, after the flue gas is cooled with AH and Flue gas cooler and the ash is removed with reused Fabric filter (FF).

The existing AH is reused. However since AH outlet gas temperature in Oxyfuel combustion increases compared to that of Air combustion, we installed the Flue gas cooler between AH and FF to control the FF inlet gas temperature. We applied condensate water (low pressure feed water) to the cooling media of the flue gas cooler.

IDF and FDF/GRF are exchanged to new one since the balance of pressure and flow rate is changed before and after retrofit.

Some RFG is used for coal transportation gas after the moisture is removed with H_2O remover in order to prevent the low temperature corrosion at Pulverized coal (PC) pipe and its temperature is raised with another AH, which is newly installed with taking countermeasure of low temperature corrosion. The existing beater type mills are reused.

The liquefied CO_2 is stored temporally in the tank at power plant site and will be transported to the CO_2 storage site by tanker lorry.

4. Progress of the Project

Regarding the boiler, the retrofit work was completed in January 2011 and currently is being commissioned in Air combustion. The plant after retrofit is shown in Figure 4.

In the commissioning of Air combustion, we had first fire by fuel oil in March 2011 and that by PC in April 2011 as shown in Figure 5. And we are now checking the static operating charastaristics, dynamic characteristics and the necessary safety tests in Air combustion. Currently we have confirmed that PC burns and newly installed equipment work without problem.

ASU is now being constructed and will be ready on October 2011 and then boiler will be commissioned in Oxyfuel combustion. CPU will be ready around the end of this year and then CO_2 will be captured. The storage of CO_2 is scheduled in next year.

The candidate of CO_2 storage site is in the process of the site selection. At this stage, the area of CO_2 storage is planning to be about 250 km to the west of the power plant site as shown in Figure 2. This area was selected because it is not far away from the power plant site, the estimated CO_2 storage capacity is sufficient, and the reservoir characteristics such as permeability and porosity are adequate for CO_2 storage. After the decision of the site and the layer, trial drilling at storage site will be implemented.

Fig.4: Plant after retrofit

Fire by fuel oil　　Fire by pulverized coal

Fig.5: First fire

5. Conclusion

We will start commissioning of Oxyfuel combustion later this year and demonstration around the end of this year. We intend to obtain the knowledge through the demonstration of Oxyfuel combustion and advance the development to the next stage promptly.

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