CO_2 Recovery Technology for Coal-Fired Power Plants

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1. Introduction

As long as fossil fuels continue to be used, CO_2 capture and storage (CCS) is an essential countermeasure against global warming. This is particularly important for coal-fired power plants because they produce relatively large amounts of CO_2. The important issues in CCS include the ability to capture large volumes of CO_2 from coal-fired power plants as well the reduction of the energy and cost required to do so. This report explains trends in CO_2 capture technologies, describes CCS projects around the world, and introduces the features of technologies developed by Mitsubishi Heavy Industries (MHI).

2. CO_2 sources[1]

About 13.5 billion tons of CO_2 are produced every year by stationary sources; this is about 60% of CO_2 emissions worldwide. Fossil-fuel CO_2 emissions cannot be effectively reduced without CCS from these stationary sources. More than 70% of the CO_2 emission from stationary sources comes from thermal power generation facilities that burn coal, gas, and oil. Therefore, a reduction in the CO_2 emissions from thermal power generation facilities would be effective in reducing overall CO_2 emissions. Coal-fired plants are responsible for 60% of the emissions from thermal generation facilities.

In other words, more than 20% of worldwide CO_2 emissions come from coal-fired power plants. Coal reserves are widely distributed, and coal is significantly cheaper than oil or natural gas. For these reasons, the quantity of coal consumed for power generation is expected to increase even further, resulting in even more CO_2 emissions. Because of this, CCS for coal-fired power plants will have a big impact on the reduction of CO_2 emissions.

3. CO_2 capture technology

3.1 CO_2 capture overview[1]

Three types of CO_2 capture systems are available (1) post-combustion CO_2 capture (post combustion), (2) oxy-fuel combustion (oxy-fuel), and (3) pre-combustion CO_2 capture (pre-combustion).

(1) Post combustion CO_2 capture

Chemical absorption is currently used to capture CO_2 from flue gases but has not been used on a large scale for recovering CO_2 from entire power plants. Other methods such as physical absorption, adsorption and membrane separation are being studied, but these have not yet been put into practical use. Currently, three practical chemical absorption methods are in operation:

- Kerr-McGee ABB Lummus Crest process, which uses 15–20 wt% monoethanolamine (MEA)
- Flour Daniel ECONAMINE process, which uses 30 wt% MEA
- the Kansai Electric Power Co., Ltd. / MHI KM-CDR process that uses KS-1 solvent

The most energy efficient process is MHI's KM-CDR process; it uses about 20% less energy than the others.

(2) Oxy-fuel

Oxygen is produced by air separation, and CO_2-rich flue gas is recirculated through the boiler to reduce the combustion temperature. The CO_2 concentration of flue gas is 80–98% by volume, enabling 100% CO_2 capture.

(3) Pre-Combustion CO_2 capture

In this method, H_2, CO, and CO_2 are generated by steam reforming of natural gas or a partial oxidation from natural gas or coal. CO is treated by a CO shift reaction to give CO_2 and H_2. After that CO_2 is separated and H_2 is produced. This method is used commercially to produce ammonia and hydrogen.

3.2 Features of MHI's CO_2 capture technology

MHI began researching and developing technology for capturing the CO_2 from the flue gases of power plants in 1990 in conjunction with Kansai Electric Power Co., Inc. One of the first issues was the reduction of the energy required for CO_2 capture. As the result of an extensive research and development program, MHI has developed many proprietary technologies including a reduced-energy solvent (KS-1), a practical reduced-energy regeneration system, and a system for the optimal integration of steam between a power-generation facility and a CO_2 capture facility.

4. Trends in CCS projects

4.1 Present situation of CCS projects

The widespread global implementation of CCS faces several hurdles. The CCS projects now underway were designed to reduce current CO_2 or future emissions, and most operate at relatively low cost. Some came about through the provision of incentives, such as the CO_2 tax in Norway, or through the use of recovered CO_2 for enhanced oil recovery, as seen in Weyburn (Canada).

4.2 Prospects for the future

CCS demonstration tests are about to begin in Europe and include a new project in Britain. CCS will not progress smoothly without demonstration tests directed by the government. In addition, widespread CCS requires finding suitable storage locations and regulatory certainty with regard to relevant laws and international rules; and economic incentive mechanisms such as CO_2 emission trading and funding.

5. MHI Experience

5.1 Commercial experience

MHI has developed the technology for capturing CO_2. Commercial achievements based on MHI's KM-CDR process include four operational natural gas-fired plants, another three plants currently under construction, and one more plant in the planning stages (**Figure 1**).

(1) Malaysia: 200 ton/day, in operation since 1999 (Petronas)
(2) Japan: 330 ton/day, in operation since 2005 (chemical company)
(3) India: 450 ton/day, in operation since 2006 (IFFCO/AONLA)
(4) India: 450 ton/day, in operation since 2006 (IFFCO/PHULPUR)

Figure 1 MHI's commercial plants

5.2 Experience with coal CO_2 capture

The commercial viability of CO_2 capture from coal-fired power plants is one of the important issues for CCS. MHI has constructed a 10-ton CO_2/day demonstration plant at a coal-fired power station in Matsushima, Japan to capture CO_2 from flue gas produced by a pulverized-coal-fired boiler. This project received funding from the Research Institute of Innovative Technology for the Earth (RITE) and was carried out jointly with the Electric Power Development Co., Ltd.

(J-POWER). MHI completed more than 4,000 hours of demonstration operation at this site in 2006 and 2007 to confirm the practicality of the KM-CDR process. Based on this success, MHI will demonstrate a medium-scale plant with a capacity of several hundred to a thousand tons of CO_2/day as the next step, with the eventual aim of developing a large-scale commercial plant.

6. Conclusion

As long as fossil fuels continue to be used, CCS is an essential countermeasure against global warming. This report has focused on technologies for the capture of CCS, introduced the trends in CO_2 capture technologies around the world, and described the features of MHI's technologies. The issues related to CO_2 capture at coal-fired power plants include reducing the energy and cost involved. MHI will continue with research and development to deal with these issues and contribute to practical countermeasures against global warming.

References

1. IPCC Special Report on Caron Dioxide Capture and Storage, 2005

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