5A2. CO_2 Recovery and Sequestration Technology

Technology overview

1. CO_2 recovery technology

(1) CO_2 recovery technology (for natural gas, syngas, and flue gas)
CO_2 separation/recovery is widely prevalent in the natural gas and syngas fields and has been carried out for decades. The CO_2 in natural gas is not only useless because it decreases the caloric value of natural gas, but also because it creates problems at LNG/ethane recovery plants by solidifying into dry ice. CO_2 is hence removed to prevent such problems.

In a plant where natural gas or naphtha is reformed to manufacture H_2, CO_2 is separated after being converted from the CO produced with hydrogen as syngas. In an ammonia/urea plant, CO_2 is separated from the gas mixture of H_2, N_2, and CO_2 to produce urea, using H_2/N_2-derived synthetic ammonia and separated CO_2.

Previously, however, CO_2 separation/recovery from flue gas was not in such large demand, finding limited applications only in food processing and dry ice. When CO_2 is separated from natural gas or syngas, the separation is relatively easy because of the high pressure of the gas. To the contrary, CO_2 separation/recovery from flue gas is difficult in many technological respects due to the very low pressure of flue gas as well as the presence of oxygen, SOx, NOx, and soot and dust in the flue gas.

(2) Necessity to recover CO_2 from fixed sources
Most fossil fuels (oil, natural gas, and coal) in the world are used as fuel for boilers, gas turbines, and internal combustion engines, releasing CO_2 into the atmosphere as exhaust gas. As a result, it is alleged that the atmospheric concentration of CO_2 has increased, resulting in global warming, which can only be prevented through the mitigation of CO_2 emissions. There are, however, many difficulties in recovering and sequestering CO_2 from movable bodies such as automobiles and vessels, naturally rendering it easier to recover CO_2 from stationary sources, like boilers, gas turbines, etc.

(3) Characteristics and superiority of technology to recover CO_2 from exhaust gas
The Kansai Electric Power Co., Inc. and Mitsubishi Heavy Industries, Ltd. began a joint R&D program in 1990 to recover CO_2 from the exhaust gas of power plants and other facilities as a global-warming countermeasure. First, they assessed the conventional "monoethanolamine" (MEA) liquid absorbent-based technology considered at that time a CO_2 recovery process that could save the largest amount of energy. It is a process developed by the former Dow Chemical Co. and later assigned to Fluor Daniel, Inc. This MEA-based technology was found disadvantageous for use in large plants as a measure against global warming because of such problems as the large amount of energy required for CO_2 recovery and the great loss in the liquid absorbent due to its rapid degradation. Kansai Electric Power and Mitsubishi Heavy Industries started with basic research to explore a new liquid absorbent, resulting in the successful development of a novel energy-saving liquid absorbent less prone to degradation. It has already been put into practical use for the manufacture of urea in Malaysia.

2. CO_2 sequestration technology

Geological sequestration and ocean sequestration are being widely studied and a commercial project of the former has already begun. Geological CO_2 sequestration is being carried out, using the Enhanced Oil Recovery (EOR) method or the coal seam sequestration-accompanied Coal Bed Methane Recovery method. Aquifer sequestration and sequestration into closed oil/gas fields are options as well, if the only objective is CO_2 sequestration. Figure 1 shows a conceptual view of CO_2 recovery-EOR combination.

CO_2-EOR commercialization started in the 1970's mainly in the United States, enhancing oil production by approximately 200,000 barrels/day. Outside the United States, Canada, Turkey, and Hungary also utilize the CO_2 recovery-EOR combination.

Underground aquifers are widely distributed on the earth wherever sedimentary layers are located. Even in Japan, where aquifers are scarce and small in structure because of Japan's volcanic and earthquake history, surveys are underway for possible CO_2 sequestration sites. If a geological underground layer has cavities, CO_2 can be sequestered in these cavities, which indigenously contain water (mainly salt water), by pumping in CO_2, thereby displacing the water. This is already underway in Norway. For Japan, Norway-like CO_2 sequestration into aquifers distributed over continental shelves are considered the most realistic.

Other than into aquifers, CO_2 can also be sequestered into closed oil/gas fields where production has already been terminated. Closed oil/gas fields once were active oil/gas fields because their geological structures did not permit oil/gas leaks. Therefore, such closed oil/gas fields are considered secure CO_2 sequestration sites.

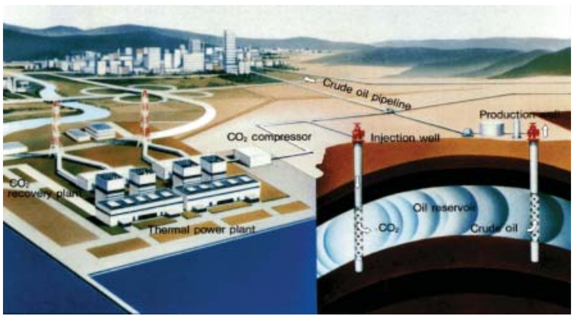

Photo 1 Conceptual view:
CO_2 recovery from power plant flue gas for EOR

Reference

Masaki Iijima et al., "CO_2 Recovery/Effective Utilization/Fixation and Commercialization," MHI Technical Journal, 39 (5), 286, 2002.