Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

HRE27-P05 Room:Convention Hall Time:May 20 15:30-17:00

A numerical simulation Study for the Distributed CCS

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Hydrogen energy is expected as energy source of the low carbon society and is utilised in fuel cell co-power generation system as a distributed generation system. Hydrogen has to be manufactured cheaply without destroying environment in order to become widespread. Producing hydrogen on a large scale is conducted in petroleum refining industry from the refinery off-gas and so on, where hydrogen is used in refinery processes. The potential of hydrogen supply from the refining industry are so large and CO_2 in high purity is constructed as by-products. The method of combining the CO_2 geological Storage of the CCS technology with hydrogen manufacture in the refining industry is proposed and examined for the low carbon society.

The purity of CO_2 produced through the hydrogen manufacturing process in the refinery has not less than 98% by the absorbing method. In order to utilise such high CO_2 purity a research work with a tentative model and the simulation of the CO_2 geological storage is conducted. The amount of CO_2 generated in an oil refinery, which is typically 100, 000 tonnes per year, is suitable for planning a small-medium size CO_2 geological storage in the distributed CCS plant.

In this research work, several subjects have been examined about the geological structure as well as the surface equipments Those subjects are bundled to aim to create a promotion model for the geological storage of a small-medium CO_2 storage. The research subjects are as follows; survey for the hydrogen generation methods, examination for the operation to inject a small amount of CO_2 (method and facility); estimation of the geological storage potential near the refinery sites; conceptual geological model for the CO_2 geological storage in or near hydrogen manufacturing unit, and simulation for the CO_2 movement in the geological storage aquifer in the model field.

Simulation was carried out in a model field for the injection of CO_2 in an amount of 100,000 tonnes per year. The simulation was conducted by TOUGH2 and the CO_2 was injected in a shallow aquifer. CO_2 is injected into a storage reservoir deeper than 800m to satisfy the super-critical CO_2 condition. However, the deep injection needs a deep injection well and the deeper the well is drilled the higher the cost becomes. Since in a small-middle scale storage the scale merit cannot be expected, the purpose of a simulation is to confirm the safety storage of a small amount of CO_2 in a shallow (200-600m) layer.

CO_2 micro-bubble seems to be the most suitable method to inject CO_2 into a shallow reservoir but there is no simulation code including the CO_2 micro-bubble characteristics. We tentatively use TOUGH2 code with the parameters as suitable to the micro-bubble as possible but the upward movement of CO_2 is expected by the buoyancy. However, if the storage is stable on this condition, it can come to a conclusion that the CO_2 in micro-bubble will be stored much safely because of the smaller buoyancy of the CO_2 micro-bubble. The simulation results inferred that gaseous CO_2 is stored in the shallow reservoir in the model field and no leakage is detected during the 20 years injection period.

The large-scale storage is expected and examined to inject an amount of 1Mt CO_2 annually for several 10 years. The large-scale CO_2 storage, however, needs not only much cost but also the large and wide CO_2 storage reservoir. The suitable storage site becomes very limited. Moreover, the local resident's agreement will become difficult to be obtained. In Asian countries, the reservoir suitable for the large-scale storage is very hard to find out. The idea to store in a small amount of CO_2 in a shallow geological layer should be adopted in the country where no storage space is expected.

This research was supported by the Japan Petroleum Energy Center(JPEC) as a technological development project supported financially by Ministry of Economy, Trade and Industry(METI).

Keywords: Distributed CCS, Geological Storage, Simulation, Petroleum refining industry, Hydrogen energy