Development of CO_2 Removal Facility Applicable to Radioactive Flue Gas from Domestic CANDU-Reactors

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1. Introduction

We have total four CANDU-reactors(Wolsong Unit 1 ~ Unit 4) under commercial operation in our country. Using heavy water(D_2O) as a shielding material (moderator) CANDU-reactors inevitably generate radioactive Carbon(C-14) by the following radiochemical reaction taking place at the vicinity of the nuclear fuels.

$$^{17}O_8 + n \rightarrow {}^{14}C_6 + \alpha \qquad (1)$$

C-14, generated by above reaction in the moderator has an extremely long half-life, 5730y, and the average energy of the β rays emitted when C-14 decays to normal Nitrogen is very high(0.156MeV). Furthermore, since Carbon is a primary element constituting the human body, ingested C-14 may be deposited in our body to cause long-term continual β -bombing of various organs. Carbon, a main component of all organisms, can be easily fixed in the tissue of various plants including the rice and enter our body inducing internal exposures. C-14 generated in CANDU-moderators moves into the cover gases, called moderator cover gas(MCG) in its oxidized form, $^{14}CO_2$, and is finally discharged into the nearby atmosphere through periodic purging of MCG. This is the known mechanism of C-14 discharge and environment contamination around the CANDU-power plants.

To reduce the C-14 level in the environment and accordingly, protect the nearby residents from radiation exposures, Korea Electric Power Research Institute (KEPRI) has been developing a reliable method to effectively remove the radioactive Carbon Dioxide from the effluent gas of MCG system. In the present paper, we introduce the status and the results of our project to develop a dry type CO_2 scrubber operated automatically and in an unmanned manner.

2. Structure and Specifications

There are four main components in our CO_2 scrubber, adsorbent columns, gas storage tank, humidity control system, and human machine interface(HMI). We use pelletized LiOH as the CO_2. About 4kg of LiOH pellets are charged in each 100mm(Φ)× 400mm(l) SUS304 cylindrical columns and there are total four columns, where each pair of columns operates in shift. The gas storage tank temporarily holds the gas during the operation and maintains the inner pressure of the system near the 1 atm. In it, the tank has a flexible bag that is made of Helium leak-free polypropylene-based materials. It depends how well the humidity of the gas is pre-controlled within an appropriate range before the contact with LiOH to get an optimized C-14 adsorption efficiency. The system has a humidity & temperature control unit which maintains the relative humidity and temperature of the gas within 40± 4% and 20± 2℃, respectively. Finally the gas actually cleaned using this facility in future applications is a radioactive one and the system must be designed to be operated in an unmanned and remote-controlled manner. This is possible by the human machine interface(HMI) of our system. It uses a RS485 modem for the bi-directional communication between the scrubber facility itself and a separate and , possibly, far-distanced operation room.

3. Operation Modes

The system has two operation modes, a circulation mode and a one-pass mode. In the circulation mode, the gas is circulating the system until its CO_2 concentration is reduced to a desired value(lower than 19ppm). On the other hand, the one-pass mode is for cleaning of the working space's atmosphere. Both modes are made up of totally seven stages including pre-conditioning stage, adsorption-removal stage, discharging stage, etc., and transfer to the next stage is done both automatically and in a manual manner. The actual screen displayed on the monitor of the operator's computer is shown in figure 2. Of course, the scrubber has a touch screen on itself and direct operation at the installed site is also possible, which is useful for the case of, for example, an emergent situation.

4. Conclusion

We have developed a CO_2 scrubber to apply it to remove radioactive Carbon Dioxide contained in the MCG or working space's atmosphere to protect the environment from the C-14 contamination and minimize the workers' exposures to β -radiation. It is composed of various units necessary for automatic and unmanned operation, which is crucial for the radiation protection of the workers. We plan to install this facility to the MCG purge lines of Wolsong Power Plants to verify if it can be used as a commercial gas-cleaning facility from both the technical and economical points of view.

There are many unsolved problems about this facility. Such problems as improvement of adsorbent's mechanical strength to prevent its flying out of the column into other components, enhancing adsorbent's CO_2-fixing capacity to reduce the frequency of column exchanges, making the whole system in a more compact shape to increase its versatility as a movable facility, etc. still remains as our future works.

REFERENCES

[1] M. J. Kabat, "Monitoring and Removal of Gaseous Carbon-14 Species," in Proc. 15th DOE Nuclear Air Cleaning Conference, CONF-780819, National Technical Information Service, Spring-field, VA, 1979

[2] H. Braun, H. Gutowski, H. bonka, and D. Grundlen, "Plant for Retention of C-14 in Reprocessing Plants for LWR Fuel Elements," in Proc. 17th DOE Nuclear Air Cleaning Conference, CONF-820833, pp. 381-399, 1983

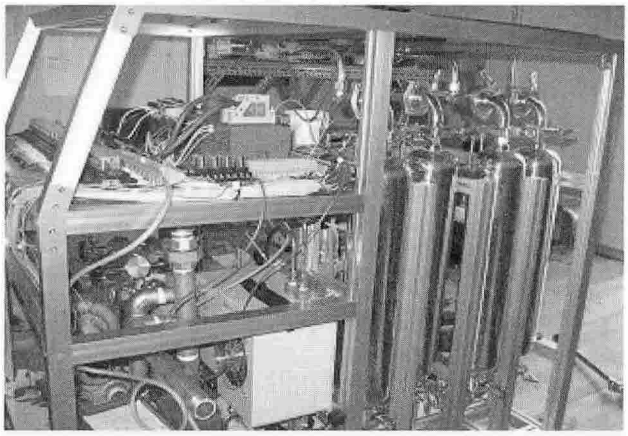

Fig. 1 The Internal View of the C-14 Removal Facility

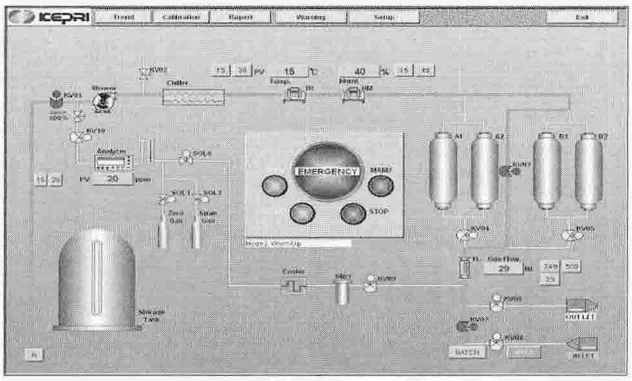

Fig. 2 The Layout of Control Panel