Study on Removal of Acid Gases from Natural Gas using Membrane Contactors, Phase II (UAE)

The study on Removal of Acid Gases from Natural Gas using Membrane Contactors was implemented by JCCP with the participation of JX Nippon Research Institute, Ltd., and with subsidy from the Ministry of Economy, Trade and Industry (METI) for technical cooperation projects in oil-producing countries. In cooperation with United Arab Emirates University as JCCP's counterpart, it was implemented over a period of five years, from fiscal 2008 to 2012.

1. Background

UAE is experiencing a surge in economic growth mainly in the oil and gas industries, but accompanying this growth are heightening concerns about global warming and environmental pollution issues. To address this situation and to conserve the environment, UAE University strongly requested a study on acid gas treatment, in close recognition of the needs of the Abu Dhabi National Oil Company (ADNOC) Group, which essentially controls the oil and gas industries in UAE. The University also proposed this study to the ADNOC Group, and captured the interest and support of ADNOC and Abu Dhabi Gas Liquefaction Co., Ltd. (ADGAS).

As the sole comprehensive national university in UAE, UAE University also serves as a research and education institution for the country's oil industry. Thus, it is an important counterpart to JCCP in strengthening UAE-Japan relations.

In light of the above-mentioned situations, implementing this study based on Japan's vast expertise in environmental countermeasure technologies in the oil industry sector has significant meaning in JCCP's efforts to strengthen the friendly relationship between the two countries.

Against this background, this study specifically focused on examining improvement measures for acid gas treatment, using ADGAS's Das Island LNG Plant as a model.

2. Overview

In Phase I of the study, which was implemented from fiscal 2005 to 2007, a test system and mathematical model for a CO_2/CH_4 two-component sample gas were developed in a university laboratory (mainly for ordinary temperatures and pressure, and partially for high pressures), to verify the potentials of membrane contactors in the acid gas removal process.

Based on the results of Phase I, Phase II initially focused on establishing a test system and mathematical model for high temperatures and pressures similar to

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operational conditions in the workplace, for an H_2S/CH_4 two-component sample gas and a $CO_2/H_2S/CH_4$ three-component sample gas. Then, the applicability of membrane contactors as a new process for acid gas removal was demonstrated at the laboratory level, and the implementation of a continuous treatment test was examined using actual gas at the Das Island LNG Plant.

(1) Acid gas removal test: A simulation test was performed in a university laboratory, envisaging the continuous treatment test to be performed at ADGAS's LNG plant using actual gas, to demonstrate the feasibility of the test. Using a hollow fiber membrane processing machine, polymeric hollow fiber membranes were produced under various conditions to achieve high-efficiency gas separation.

(2) Development of a mathematical model: Again envisaging the continuous treatment test to be performed at ADGAS's LNG plant using actual gas, the high-temperature, high-pressure membrane contactor $CO_2/H_2S/CH_4$ absorption model was modified, and a simulation was performed to validate the model using test data.

(3) Examination of field test equipment: Safety measures for the field test equipment were examined, a preliminary design was produced, and the quantity survey was reviewed, once again envisaging the continuous treatment test to be performed at ADGAS's LNG plant using actual gas.

The results of the study can be summarized as follows.

(1) The production technology and characteristic evaluation technology for polymeric hollow fiber membranes were transferred to the UAE side.

(2) Hollow fiber membranes that could withstand pressures as high as 50 bar were successfully produced, and an acid gas removal test was successfully completed at a gas temperature of 50°C and an absorbent temperature of 100°C, which resemble actual conditions at the ADGAS plant, using an eight-component gas mixture and a three-component adsorbent. (World first)

(3) A complex and precise mathematical model for acid gas removal using membrane contactors was developed in consideration of physical, thermal and momentum balances, and a numerical solution was successfully achieved from the model. (World first) The predicted values derived from the model closely corresponded to the test data, and were able to be used in the simulation performed in the field test.

(4) The continuous treatment test to be performed at the ADGAS plant using actual gas was examined, the preliminary design, including safety measures for field test equipment, was completed, and a preliminary estimate of the manufacturing cost of field test equipment was prepared. The field test equipment was unable to be produced in this study, but ADGAS has shown an interest in implementing the field test.

3. Observations (Summary)

This study on acid gas treatment by membrane separation was implemented with the aim of improving ADGAS's Das Island LNG Plant, which provides large supplies of LNG to Japan. It was completed successfully

with highly significant results, owing to the extensive efforts of many people, including Dr. Mohamed Al-Marzouqi, chief researcher, other researchers at UAE University, and laboratory assistants.

The results of the study have been reported every six months at the Scientific Council Meeting held regularly for evaluation by Dr. Gharib Aly, Professor Emeritus at Lund University, who is also an advisor for JCCP. After evaluation, the results have also been disclosed to members of UAE University, ADGAS engineers and other parties concerned, as appropriate, and were presented at the Joint GCC-Japan Environment Symposium hosted by JCCP in fiscal 2011. On the Japanese side, the study received research guidance from Dr. Masaaki Teramoto, Professor Emeritus at Kyoto Institute of Technology, and Dr. Hideto Matsuyama, Professor at the Department of Chemical Science and Engineering, Graduate School of Engineering, Kobe University.

It is hoped that technical exchanges that have been held among members from UAE University, ADGAS, JX Nippon Research Institute and other organizations concerned in the increasingly important environment sector and the results that have been obtained through this study have helped to promote even greater cooperation between UAE and oil-related organizations in Japan.

A Scientific Council Meeting held at UAE University

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