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Energy Procedia 4 (2011) 1347–1352

**Energy
Procedia**

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GHGT-10

New Energy Efficient Processes and Improvements for Flue Gas CO₂ Capture

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Abstract

The Kansai Electric Power Co., Inc. (KEPCO) has developed energy efficient chemical absorbents and economical processes which aim to reduce the cost of CO₂ capture, in collaboration with Mitsubishi Heavy Industries, Ltd. (MHI). Together the companies have been developing and critically testing high efficiency, economical absorbents according to the latest absorbent development procedures and process simulation for CO₂ capture processes. This work has been ongoing since 1991, using several Japan based R&D facilities and a pilot plant, used to verify improvements, located at Nanko Power Station in Osaka, Japan. Following significant testing of a range of absorbents in the mid 1990s, KS-1TM, KS-2 and KS-3 were developed. Based on subsequent rigorous evaluation of the three solvents, KS-1TM was selected for commercialization because of its overall technical and economical merits. During long-term pilot plant testing, the improved absorbents demonstrated superior performance in relation to the regeneration energy requirements leading to the following results: 2.94MJ/kg-CO₂ in combination with KS-1TM and the Kansai Mitsubishi Carbon Dioxide Recovery (KM-CDR ProcessTM) commercial process. In addition, practical, commercially applicable improved absorbent properties such as low corrosiveness and low solvent consumption were also confirmed. KEPCO and MHI continue development work in this area and the current status is summarized as follows: The highly successful R&D phase has led to the commercial deployment of CO₂ capture technology and seven (7) commercial CO₂ capture plants are currently under operation, with a maximum CO₂ capture capacity of 450 metric tons per day (tpd). These commercial plants are deployed in the chemical and fertilizer industry, where the operational performance is assisting in the improved development of R&D concepts. Two (2) further commercial plants are under construction, with commissioning expected in Q3 2010.

For further cost reductions in relation to CO₂ capture, recent work has focused on developing new energy efficient chemical absorbents and processes. Following modifications to the Nanko CO₂ capture pilot plant a new "Energy Saving Process", was developed, which leads to a greater than 10% steam consumption reduction over the MHI conventional process using KS-1TM absorbent. Additionally the same reduced steam consumption was recorded for tests using the KS-1TM absorbent. A thermal energy requirement of less than 2.5 MJ/kg-CO₂ in combination with KS-1TM and the "New Energy Efficient Process" has been confirmed under the optimum operation condition of the CO₂ capture process. In addition to select new absorbents which feature the best profile and fit to the actual operating condition, KEPCO and MHI have intensively evaluated vapor-liquid equilibrium (VLE) and reaction kinetics for a range of newly developed absorbents and their performance is presented in this paper. The above data was obtained using the Nanko CO₂ capture pilot plant which operates under a natural gas fired boiler condition and we expect that the thermal energy requirement of coal fired boiler flue gas (with greater CO₂ concentration condition) will be further reduced.

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doi:10.1016/j.egypro.2011.01.193

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KEPCO and MHI are continuing pilot tests for the "Energy Saving Process", leading to the application of this new process in commercial CO₂ capture plant design. This paper introduces and presents the current status of the KEPCO & MHI CO₂ capture technology and concepts for future energy reduction improvements. The paper will also include test results in relation to newly developed absorbents, and the "New Energy Efficient Process", which have enhanced the performance and reduced the associated energy penalty of the CO₂ capture process. KEPCO and MHI are continuing the development of efficient absorbents and optimized processes, thus helping to facilitate the future wide scale deployment of CO₂ capture technology as an effective counter measure against global warming.

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Keywords; KEPCO, MHI, global warming, CO₂ capture, solvent, technological improvements, energy saving

1.0 Introduction and Background

In response to issues concerning global warming and the contribution of industrial CO₂ into the earth's atmosphere, Kansai Electric Power Company (KEPCO) and Mitsubishi Heavy Industries, Ltd. (MHI) have been working together since 1990 to develop an advanced CO₂ capture chemical absorption process which can be applied to the power generation sector as an effective and economic means to reduce industrial CO₂ emissions.

2.0 CO₂ recovery pilot plant at the Nanko Power Station

The pilot plant was installed at KEPCO's Kanko Power Station, located in Osaka, in 1991.

The Nanko Power Station is fired by liquefied natural gas (LNG) and the CO₂ content in the flue gas is about 10% and is almost atmospheric pressure. Figure 1 shows the view of the CO₂ capture pilot plant, and the corresponding specifications and process flow schematic are shown in Table 1 and Figure 2 respectively.



Figure 1. Nanko CO₂ capture Pilot Plant

Table 1. Specification of Nanko Pilot Plant

Description	Unit
Flue Gas Flow Rate	600 Nm ³ / h (1/3000 of 600MW flue gas)
CO ₂ Recovery Volume	2 tpd
CO ₂ Recovery Rate	90 % (design basis)
Recovered CO ₂ Purity	99.9 %

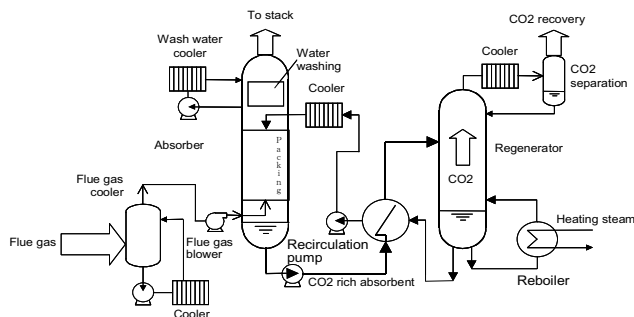


Figure 2. Process flow of Nanko CO₂ capture pilot plant

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