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New Energy Efficient Processes and Newly Developed Absorbents for Flue Gas CO₂ Capture

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Abstract

The Kansai Electric Power Co., Inc. (KEPCO), in collaboration with Mitsubishi Heavy Industries, Ltd. (MHI), has developed a variety of energy efficient chemical absorbents and economical processes (KM CDR ProcessTM) which aim to reduce the cost of CO₂ capture. This work has been ongoing since 1991, using several Japan based R&D facilities, a CO₂ capture pilot plant, located at Nanko Power Station in Osaka, Japan and a large scale demonstration plant at Southern Company's Plant Barry.

Highly successful R&D has led to the rapid commercial deployment of ten (10) currently active, KM CDR ProcessTM, commercial CO₂ capture plants. In addition one (1) plant is now under construction in Qatar (commissioning in 2014). These commercial plants are deployed exclusively in the chemical and fertilizer industries. The KM CDR ProcessTM and KS-1TM have also been utilized at the large scale CCS demonstration plant in the USA, the 500 tons per day (tpd) Southern Company Project, the first project in the world to demonstrate black coal 'full chain' CCS. Application for both natural gas and Coal flue gas highlights the versatility and robustness of both the solvent and the process.

Recent work has focused on further developing energy efficient chemical absorbents and reducing the energy penalty for further cost reduction. To select absorbents which feature the best profile and fit to the actual operating conditions KEPCO and MHI have intensively evaluated the vapour-liquid equilibrium (VLE) and reaction kinetics for a range of newly developed absorbents. One of these absorbents has a reaction rate 1.4 times faster than that of KS-1TM, while having similar CO₂ loading and reaction temperatures. The thermal energy requirement for CO₂ recovery was reduced by 9% compared with KS-1TM to 1.19 t-steam/t-CO₂ (in-plant auxiliary steam which corresponds to LP steam) following testing at the Nanko pilot plant using the combination of this absorbent and the commercial KM CDR ProcessTM. In parallel with these developments, KEPCO and MHI have continued to improve the KM CDR

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ProcessTM by optimizing the pilot plant and further improving the thermal energy requirement to 1.09 t-steam/t-CO₂ (in-plant auxiliary steam which corresponds to LP steam).

In 2011, modifications to the Nanko CO₂ capture Pilot Plant lead to the development of a new commercial application termed the “*New Energy Efficient Process 3*” or “*NEEP3*”. The combination of the newly developed absorbents and “*NEEP3*” achieved the lowest yet thermal energy requirement, 1.00 t-steam/t-CO₂ (in-plant auxiliary steam which corresponds to LP steam). During the same testing period, KS-1TM achieved a thermal energy requirement of 1.03 t-steam/t-CO₂ (in-plant auxiliary steam which corresponds to LP steam).

This manuscript introduces and presents the current status of the KEPCO/MHI CO₂ capture technology and concepts for future energy reduction improvements. The paper also includes test results in relation to the newly developed absorbent, and the “*NEEP3*” described above, which has enhanced the performance and markedly reduced the energy penalty of the CO₂ capture process. KEPCO and MHI are continuing the development of efficient absorbents and optimizing processes, thus helping to facilitate the future wide scale deployment of CO₂ capture technology as an effective counter measure against climate change.

Keywords: KEPCO; MHI; post combustion CO₂ capture; KS-1TM; technological improvements; energy penalty; global warming

1.0 Introduction and Background

In response to climate change issues and the contribution of industrial CO₂ into the earth’s atmosphere, KEPCO and 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 Nanko Power Station, Osaka, in 1991. The Nanko Power Station fires liquefied natural gas (LNG), the CO₂ content in the flue gas is approximately 10% at almost atmospheric pressure. Figure 1 shows 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

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