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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 which aim to reduce the cost of CO2 capture. The companies have been jointly developing and critically testing high efficiency, economical absorbents according to the latest absorbent development procedures and process simulation for post combustion CO2 capture processes. This work has been ongoing since 1991, using several Japan based R&D facilities and a CO2 capture pilot plant, used to verify improvements, located at Nanko Power Station in Osaka, Japan. As a result, the improved absorbents: KS-1™, KS-2 and KS-3 along with the commercial KM CDR Process™ have been developed. 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-1™ and the KM CDR 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 of these activities is summarized as follows;

The highly successful R&D phase has led to the rapid commercial deployment of the KEPCO/MHI CO2 capture technology and eight (8) commercial CO2 capture plants are currently under operation, with a maximum CO2 capture capacity of 450 metric tons per day (tpd). In addition two (2) additional commercial plants are now under construction in Pakistan and India and are due for commissioning in 2011 and 2012 respectively. These commercial plants are deployed in the chemical and fertilizer industry, where the operational performance is reflected into improved process designs and enhanced R&D concepts.

For further cost reductions, in relation to CO2 capture, recent work has focused on further developing energy efficient chemical absorbents and processes. To select 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. One of these absorbents has a reaction rate constant 1.4 times faster than that of KS-1™ having similar CO2 loading properties, and reaction heat with CO2, compared with KS-1™. The thermal energy for CO2 recovery was reduced by 9% compared with KS-1™ to 2.67 MJ/kg-CO2 following testing at the Nanko pilot plant using the combination of this absorbent and the commercial KM CDR Process™.

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In parallel with these developments, KEPCO and MHI has continued the optimization of the pilot plant operating condition and further improvements of thermal energy to 2.5MJ/kg-CO2, in combination with newly developed absorbents and the commercial KM CDR Process™ has been achieved.

Following modifications to the Nanko CO2 capture Pilot Plant the above operational condition was achieved leading to the development of a new commercial application (termed the "*New Energy Efficient Process*"). A thermal energy requirement of <2.5 MJ/kg-CO2 in combination with KS-1™ and the "*New Energy Efficient Process*" has been confirmed under the optimum operation condition of the CO2 capture process. The best performance result (2.31 MJ/kg-CO2) of this new process was achieved during a specific test program in 2010.

This manuscript 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 the newly developed absorbent, and the "*New Energy Efficient Process*" described above, 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.