1st Post Combustion Capture Conference

Development of Carbon Dioxide Removal System from the Flue Gas of Coal Fired Power Plant

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1. Introduction

Post-combustion carbon dioxide capture is the technique that can be rapidly and safely employed for substantially reducing carbon dioxide emissions from existing and near future power plants. The key question of the absorption/desorption technique for carbon dioxide removal is process economics. Toshiba is pushing through the post-combustion carbon dioxide capture because it can be employed in rather short period and applied for both retrofit and new power plants. In this work, we evaluated the seven amine-based absorbents as new solvents, which was selected from about 900 amines, in terms of energy consumption for CO_2 desorption using a thermodynamic absorption and desorption cycle simulation. We estimated the consumed energy in the stripper when the flue gas contains 12 % CO_2 and the capture ratio of CO_2 from the flue gas is 90 %. It was found that the lowest energy consumption in the stripper was about 2.5 GJ/t- CO_2 when one mixed amine-based aqueous solution (Toshiba Solvent 2, TS-2) was used as the solvent. The value was much lower than that for the general 30 wt. % monoethanolamine (MEA) aqueous solution. And it is lower than our former solvent (Toshiba Solvent 1, TS-1).

Then we evaluated the new solvent TS-2 using the bench-scale test facility which contains a complete absorption/desorption process with the absorber and the stripper. At this test TS-2 showed lower consumed energy, less than 2.5 GJ/t-CO_2, by optimizing the space velocity of the simulated flue gas and so on, while TS-1 showed about 2.7 GJ/t-CO_2 which is nearly equal of the value of the thermodynamic simulation.

Parallel to these activities the pilot plant of 10 t-CO_2/day recovery was constructed and commenced in September 2009 with a complete absorption/desorption supplied with the flue gas of the Mikawa coal fired thermal power plant located in Fukuoka, Japan. In the demonstration tests CO_2 capture ratio and captured CO_2 rate exceeded the planning

values of 90% and 10t-CO_2/day each during continuous 3,000 hour operation. And the energy consumption for CO_2 recovery at the stripper had been kept between 3.2 and 3.3 GJ/t-CO_2.

Based on these test results, we had found the improved system structure of the pilot plant to reduce the consumed energy in the stripper by the thermodynamic cycle simulation. Then we had redesigned and reconstructed the pilot plant. As a result, the latest tests showed far lower energy of less than 2.8 GJ/t-CO_2 with exceeded values of 90% CO_2 capture ratio and 10 t-CO_2/day captured CO_2 rate using our developed solvent TS-1. According to the heat loss tests and analysis, it is expected that the consumed energy would be reduced more 0.3 GJ/t-CO_2 by reinforcing the thermal insulation at the pilot plant, which means around 2.5 GJ/t-CO_2 would be possible at the larger scale plants.

It is the first time in the world that the consumed energy of much lower than 3.0 GJ/t-CO_2 has been proved at a 10 t-CO_2/day scale pilot plant using the actual flue gas of the coal fired power plant, not only by simulations.

On the other hand the concentrations of degraded substances, such as ions of several organic acids, sulphate, sulphite, nitrite and so on, had been increasing within TS-1 solvent because of the degradation by the oxygen, SOx and NOx in the flue gas. But no corrosion has been found in the equipments and pipes using stainless steel materials inside the system after 3,000 hour operation.

These results prove that Toshiba CO_2 capture system using TS-1 solvent is a promising system which has been realizing good performances and not degraded during its continued operations under actual flue gas. Toshiba will utilize the results of these studies to further improve and optimize the performance of the system, towards implementation and integration of the system to a larger scale thermal power plant system.

2. References

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