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Impact of the aerosol particle included in actual flue gas on amine mist formation/growth in the Post-Combustion Capture Pilot Plant

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Abstract

In this study, Toshiba conducted evaluation of amine emissions from 10ton-CO_2/day scale pilot plant within 30wt% MEA solution as well as Toshiba solvent (TS-1), as part of the project by the Ministry of the Environment (Japan). The results show that TS-1 developed by Toshiba has significant advantages over a 30wt% MEA solution in terms of mitigating amine emissions from the top of the absorber. On the other hand, it was found that mist-driven amine emissions are less likely to be reduced by water wash and acid wash, compared to vapour pressure-driven amine emissions. We also verified the role of aerosol contained in the raw flue gas on amine mist formation/growth in the CO_2 absorber. As a result, it is interesting to note that remarkable increase in number concentration of the amine mist from the top of the 1st tower (water wash) was observed, depending on the increase in number concentration of the aerosol in the flue gas upstream of the absorber. Additionally, the aerosol is nano-order, which is much smaller than that of amine mist (micro-order), and the fluctuation tendencies of the peak diameter of both the aerosol and amine mist were very similar. Therefore, this might indicate that the aerosol acts as a source of amine mist nuclei and enhances amine mist growth in the CO_2 absorber.

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Keywords: amine emissions, aerosol, amine mist, post combustion

1. Introduction

In recent years, climate change resulting from an increase of CO_2 concentration has become one of the most important environmental issues in our time. One-fourth of CO_2 generation source comes from the power generation sector, and is particular the burning of fossil fuels in thermal power plants.

Amine base post-combustion CO_2 capture is a promising technique that can be rapidly and safely employed in

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order to ensure a substantial reduction in carbon dioxide emissions from existing and near future power plants. Based on this understanding, Toshiba has focused on developing post-combustion CO_2 capture technology since 2007, and has designed and constructed a 10ton-CO_2/day scale pilot plant at the Mikawa coal fired thermal power plant run by Sigma Power Ariake Co. Ltd. In September 2009, the test operation started with actual flue gas to verify the performance of the system, as well as absorbents such as Toshiba solvent (TS-1) [1] [2].

CCS plants must strive for near-zero amine emissions; there are two main reasons for this. Firstly, amine emissions pose serious environmental risks, with the resulting by-products being potentially more toxic than the parent amines themselves. The photo-oxidation of selected amines by NOX, HNO_3, O_3 can produce nitrosamines and nitramines, which are very likely to be carcinogenic. Secondly, the make-up costs for lost amines would be quite expensive, depending on the kind of amine. Therefore, it is crucial to reduce amine emissions in order to enable employment of full-scale CCS plants.

In this study, as part of the project by the Ministry of the Environment (Japan), Toshiba conducted an evaluation of amine emissions from the 10ton-CO_2/day scale pilot plant within 30wt% MEA solution as well as Toshiba solvent (TS-1). The emission mitigation systems, such as water wash and acid wash, have been tested under real power plant operating conditions. In addition, we carried out a study on the impact of the aerosol particle included in actual flue gas on amine mist formation/growth in the CO_2 absorber.

2. Testing program on the pilot plant at Mikawa coal fired thermal power plant

Figure 1 shows the schematic drawing of PCC Pilot Plant in Mikawa Power Plant. Actual flue gas for the pilot plant is introduced from the existing coal-fired power plant, and the decarbonated flue gas is returned to the Power Plant. The water wash above the absorber is utilized to capture amine components contained in exhausted gas from the top of the absorber, in order to reduce amine emissions to the atmosphere from the stack. In addition, a part of the exit gas (about a twentieth) from the top of the water wash is introduced to the testing apparatus, which has the 1st tower (additional water wash) and the 2nd tower (acid wash), to study methods for further reduction of amine emissions.

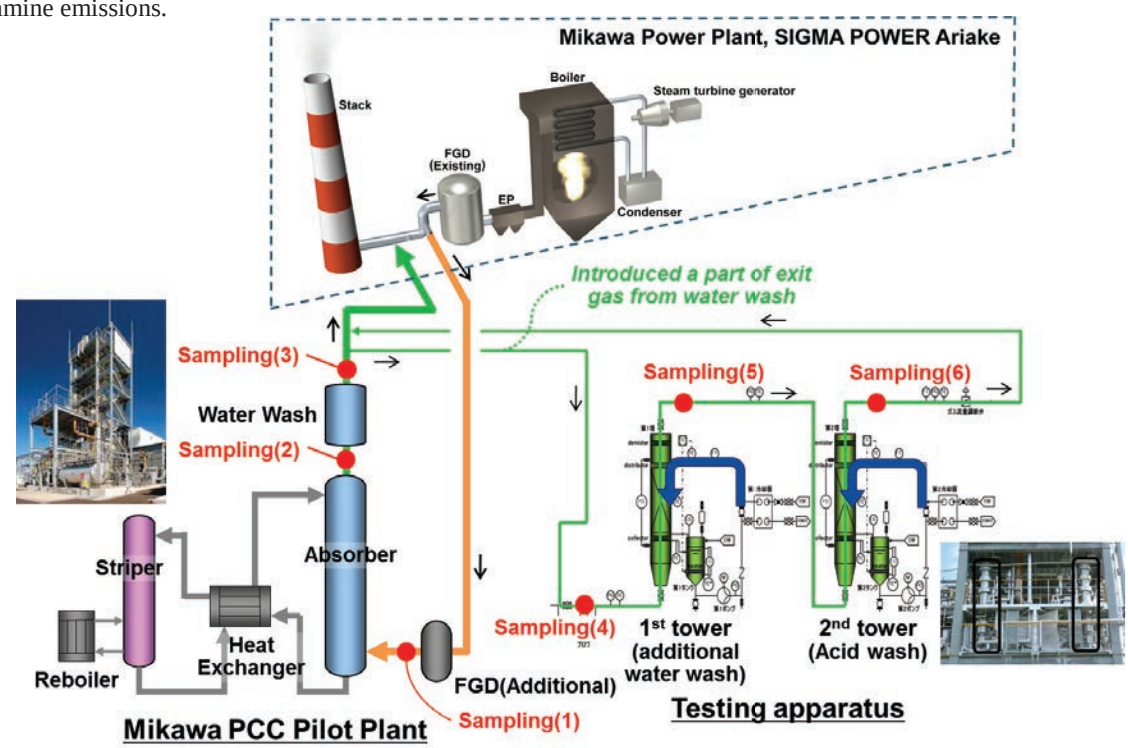

Figure 1Schematic drawing of PCC Pilot Plant and Testing apparatus for evaluation of amine emissions