

MERCURY EMISSION CONTROL BY WET SCRUBBER WITH SUPER STATIC MIXER

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Abstract:

In pulverized coal combustion, the volatility of mercury and its compounds are emitted during combustion. In general, emissions of mercury from coal combustion sources are approximately 20–50% elemental mercury (Hg^0) and 50–80% divalent mercury (Hg^{II}), which may be predominantly HgCl_2 . Hg^{II} is water-soluble and may be removed from the flue gas by wet FGDs and dry deposition close to combustion sources, while Hg^0 is diffused in atmosphere because Hg^0 has a high vapor pressure and low water-solubility. To reduce mercury levels in the environment and human exposure, the removal techniques are desired. The main objective of this work is to investigate the influence of oxidation and absorption conditions on mercury removal efficiency to establish effective measures for mercury removal. The wet scrubber employed in this study is a unique design having a static mixer stirring flue gas and solvent.

In experiment, model gas mixtures ($\text{Hg}^0/\text{O}_2/\text{N}_2$ system and $\text{Hg}^0/\text{O}_2/\text{NO}/\text{N}_2$ system) were prepared at room temperature. The model gases were oxidized by ozone generated by atmospheric plasma before treatments by the wet scrubber. Elemental mercury was converted to HgO by reaction with ozone at room temperature, and above 99% Hg^0 removal was attained by the wet scrubber. Simultaneously, removal of NO was examined as a multipollutant control technology. Nitrogen oxide in the model gas was converted to NO_2 by reaction with ozone, and about 90% NO removal was obtained by using the wet scrubber.

Background

Extensive efforts have been made over the past few years to remove mercury in flue gas from coal-fired plants. The most widely tested method for mercury removal is powdered activated carbon injection (PAC) into flue gases. However, it is generally recognized that the PAC injection has some drawbacks such as high cost, narrow working temperature window, and insufficient capacity of adsorption. Therefore, alternative techniques converting water-soluble mercury such as injection of the oxidizing agents and electrical oxidation by using non-thermal plasmas have been studied. Above all, mercury oxidation techniques by ozone injection have an appeal for simultaneous removal of $\text{NO}_x/\text{SO}_2/\text{Hg}$.

We have been developed the radical injection methods by using non-thermal plasmas or emission of vacuum ultra violet to remove NO_x in flue gases. In this method, NH_i radicals (NH_2 , NH , and N) are generated by plasmas in the flow of an ammonia gas, and are injected into a flue gas containing NO_x . The injected NH_i radicals react with the NO_x via an elementary chemical reaction, wherein NO_x is eventually converted to N_2 and NH_4NO_3 . Since the discharge power is only used for exciting of the ammonia agent, the power consumption of the plasma is extremely low. Hence, the De NO_x process is substantially more energy efficient than other discharge technologies.

This research is an application study of the radical injection techniques. Oxygen radical and ozone generated by using a dielectric barrier discharge (DBD) were injected into model gases containing elemental mercury and nitrogen oxide at room temperatures. Effects of plasma conditions (applied voltage) and absorption conditions (liquid/gas ratios) on the NO/Hg removal were investigated.

Experiment

Figure 1 depicts a schematic diagram of the ozone injection test facility using the pulsed DBD plasma. The facility contains two quartz tubes for gas mixing and oxidation, the ozone injector, the gas feed systems, and gas analyzers

(NO_x/O₂, N₂O, and Hg⁰ analyzer). The quartz tubes for gas mixing and oxidation have a 46 mm inner diameter, and are 500 and 600 mm in length, respectively. **Figure 2** depicts the configuration of the mixing chamber and the ozone injector. The ozone injector is inserted into the reaction chamber, which is 61 mm in diameter and 490 mm long. The electrodes of the ozone injector are coaxial in configuration, with quartz glass tubes as the dielectric materials. The high voltage electrode, which is 50 mm in diameter and 500 mm long, is set into the inner quartz tube. The outer tube is 61 mm in diameter, 2 mm in thickness, and 490 mm in length. The grounded electrode, which is 360 mm long and 0.2 mm thick, covers the outer side of the outer glass tube. O₂/Ar gas mixture (30% O₂) is fed into the 1.5 mm gap of the injector, and DBD plasma was generated in the gap. A pulsed, one-cycle sinusoidal (OCS: Haiden Lab., PHF-2KL) output was employed as the power source for generating the atmospheric DBD plasma. The applied voltage and the discharge current are defined as the peak-to-peak values. The duration of one cycle of the waveform was approximately 10 μs during the experiments, while the repetition rate was fixed at 10 kHz. The discharge firing voltage of the O₂/Ar gas mixture was 13.5 kV. The wet scrubber with a static mixer was employed in this study to obtain high efficiency of mercury absorption.

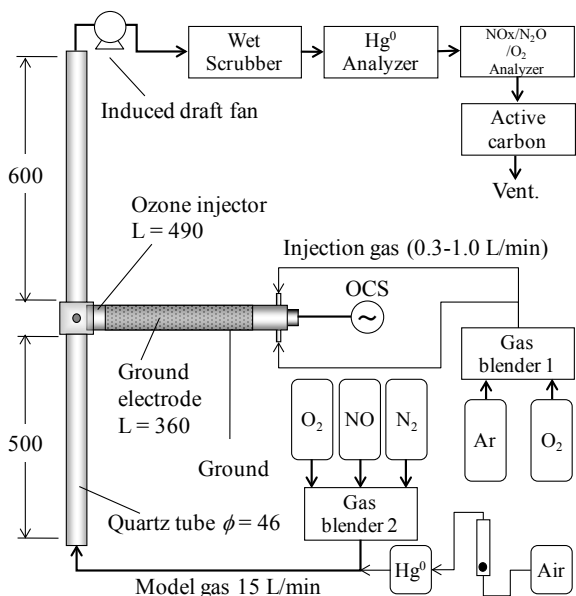


Fig.1. Experimental setup.

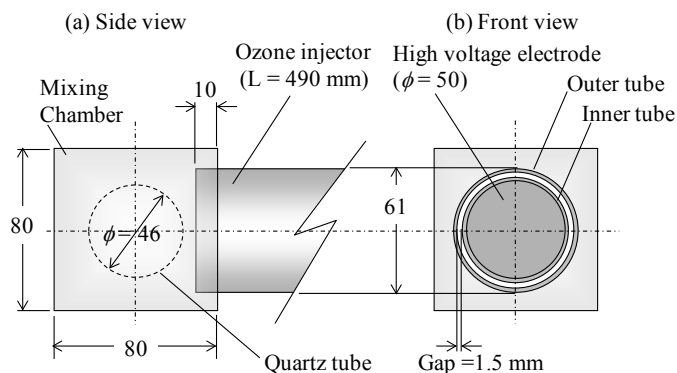


Fig.2. Detailed configuration of the ozone injector.

Results and discussion

Figure 3 provide a clear basis for effects of the applied voltage and liquid/gas (L/G) ratios in the wet scrubber during ozone injection tests. High mercury removal was observed at the applied voltage of 14 kV and a gradually increase for progressively greater applied voltages. A higher percentage of Hg removal was obtained at the highest applied voltage, the highest O₂/Ar flow rate, and the highest L/G ratio. An increase of the applied voltage and the O₂/Ar flow rate causes an increase of the ozone concentration; it is likely that Hg oxidation is strongly promoted by high ozone concentration. The effect of L/G on Hg removal can be explained by an increase of the contact efficiency between gas and liquid in the wet scrubber.

Characteristics of NO removal by ozone injection were similar to trends shown in Fig.3. About 90% NO removal was attained in simultaneous removal of NO/Hg. It found that ozone injection system combined with the wet scrubber was available for simultaneous removal of Hg and NO.

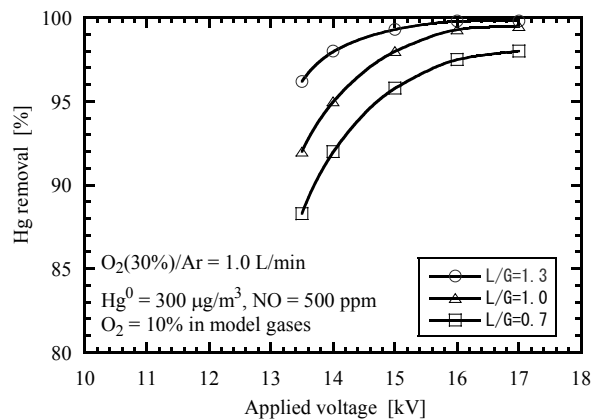


Fig.3. Hg removal by ozone injection with wet scrubber.