Study of Carbon Monoxide Oxidation by Discharge

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Abstract: In semi-closed space such as highway tunnel, diesel exhaust particles (DEP) and carbon monoxide are high concentration. DEP is removed by the electrostatic precipitator (ESP), and carbon monoxide is diffused by the ventilation fan in ventilation tower. Recently, underground tunnel type expressways have been constructed in under area. It is necessary to raise the ventilative tower because many people live in this area. The ventilation tower lowers when the carbon monoxide can be removed even a little. Therefore, the decrease technology of the carbon monoxide is requested. In this work, the conversion of carbon monoxide to carbon dioxide by dielectric barrier discharge (DBD) and corona discharge has been experimentally investigated.

The experimental results are as follows. A carbon monoxide conversion in a wet condition was higher than that in a dry condition. Two-stage wire corona discharge reactor is 20% at 3.5 W carbon monoxide conversion more than one-stages. It was 50% at 3.5 W carbon mon-oxide conversion at by for DBD.

Keywords: carbon monoxide, corona discharge, dielectric barrier discharge, wet condition

1 INTRODUCTION

In semi-closed space such as express highway tunnel or underground tunnel and so on, noxious fume of particulate substance of diesel exhaust particles (DEP), carbon monoxide etc. exists by high concentration. If DEP obtain entrance into apparatus respiratorius, it will have a bad influence on health, such as causing a cancer and embarrassment. If carbon monoxide is taken in a human body, it reduces the oxygen concentration in blood. Then, headache, vomiting, and bad condition are caused. People may die from 1000 ppm of carbon monoxide concentration. Therefore, in order to prevent these substances in the allowable range, air ventilation is performed.

Now, at express highway tunnel of mountain, electrostatic precipitator (ESP) is used to clear DEP. On the other hand, carbon monoxide is exhausted to air prevented below 100 ppm of carbon monoxide concentration by ventilation fan of ventilating tower. However, at underground tunnel in capital sphere of completion schedule from now on, if it uses the traditional system, it is said that carbon monoxide is dangerous on a human body because of the ground is people and construct of narrow quarters. So, there are problems that construction cost and power cost of ventilating tower is very expensive. Thus, establishment of carbon monoxide conversion technology is required from now on. However, there is hardly any report of carbon monoxide conversion [1]-[3].

In this work, carbon monoxide conversion to carbon dioxide by dielectric barrier discharge (DBD) and corona discharge has been experimentally investigated. The carbon monoxide concentration was measured before and after treatment, and examined the effect of carbon monoxide conversion.

2 EXPERIMENTAL SYSTEM

A schematic of experimental system using this work is shown in Fig. 1. Three kinds of sample gas were used, carbon monoxide gas of N_2 dilution (carbon monoxide concentration: 300 ppm), O_2 gas and N_2 gas. Each gas flow rate was controlled by a flow controller. Carbon monoxide initial concentration and gas flow rate were 150 ppm, 400 mL/min. A moisture containing gas to be used in the drying step, having a water volume 14 g/m^3, can be obtained by bubbling a desired gas in water. Those gases were mixed in the mixing chamber at upstream of the DBD reactor.

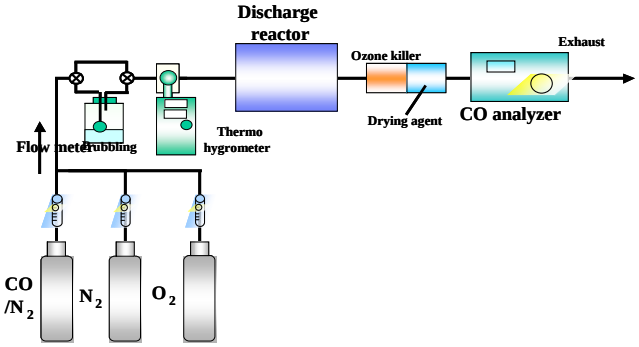

Fig. 1 A schematic of experimental system

Carbon monoxide concentration in the sample gas was measured by the carbon monoxide analyzer (Model 48-C Thermo Environmental Instruments) before and after treatment. Water Volume in the sample gas was measured by the thermohygrometer (SK-140TRH). Manganese dioxide, silica gel was installed in the upstream of carbon monoxide analyzer because of ozone, moisture has a possibility of damaging carbon monoxide analyzer.

2.1 Discharge Reactors

A schematic diagram of the DBD reactor using this work is shown by Fig. 2. The structure of the DBD reactor was a shape of a double coaxial cylinder. The high voltage electrode was formed by the outside of glass cylinder was covered with an aluminum foil. The grounded electrode was stainless pipe. The gap length was 1.5 mm and electrodes length was 180 mm. The barrier discharge is formed by AC high voltage applied between electrodes gap. Discharge power was measured with Lissajous figure by an oscilloscope.

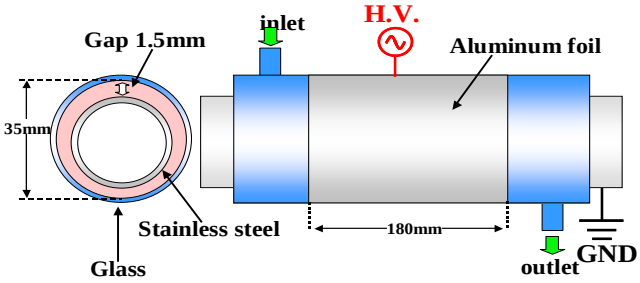

Fig. 2 A schematic diagram of the DBD reactor

The structure of the corona discharge type reactor is shown in Fig. 3. The high voltage electrodes were wire, the grounded electrode used two plates (made of stainless-steel, 60 mm^2 ×62 mm^2). The gap length was 9.5 mm. Discharge current was 0.1-0.3 mA. Discharge power is product of discharge current and applied voltage.

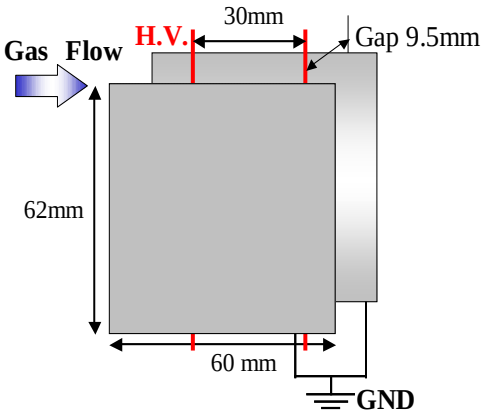

Fig. 3 A schematic diagram of the corona discharge type reactor

2.2 Characteristic of Carbon Monoxide Conversion by DBD

In this section, when changing water volume in gas, the effect of carbon monoxide conversion was examined. Gas flow rate in the DBD reactor was 400 ml/min, carbon monoxide initial concentration was 150ppm and water volume was dry, 6 g/m^3, 14 g/m^3. Carbon monoxide conversion as a function of discharge power for dry condition or humid condition is shown in Fig. 4. From this characteristic, within any water volume, the carbon monoxide conversion increases with increasing discharge power. The carbon monoxide conversion also increases with increasing water volume and it becomes about 50% at 3.5 W. It is considered that OH generated from H_2O oxidizes carbon monoxide [4]-[5].

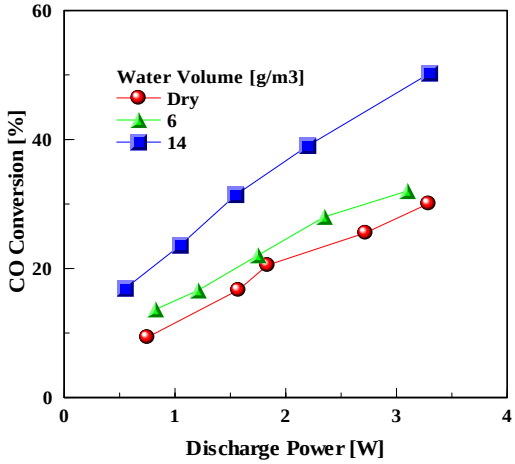

Fig. 4 CO conversion as a function of discharge power for dry condition or humid condition (DBD)

2.3 Characteristic of Carbon Monoxide Conversion by One-stage Wire Corona Discharge

Gas flow rate in the corona discharge type reactor was 400 mL/min, carbon monoxide initial concentration was 150 ppm and water volume was dry, 14 g/m^3, 18 g/m^3. Carbon monoxide conversion as a function of discharge power for dry condition or humid condition is shown in Fig. 5. From this characteristic, within any water volume, the carbon monoxide conversion increases with increasing discharge power. The carbon monoxide conversion also increases with increasing water volume and it becomes about 20% at 3.5 W. The effect of the water volume in corona discharge is lower than that in DBD.

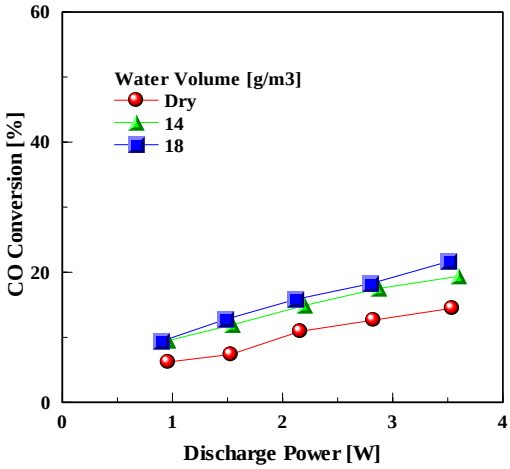

Fig. 5 CO conversion as a function of discharge power (One-stage wire corona discharge)

2.4 Characteristic of Carbon Monoxide Conversion by Two-stage Wire Corona Discharge

Gas flow rate in the corona discharge type reactor was 400 mL/min, carbon monoxide initial concentration was 150 ppm and water volume was dry, 14 g/m^3. Carbon monoxide conversion as a function of discharge power for dry condition or humid condition is shown in Fig. 6. From this characteristic, within any water volume, the carbon monoxide conversion increases with increasing discharge power. The

carbon monoxide conversion also increases with increasing water volume and it becomes about 20% at 3.5 W. carbon monoxide conversion in two-stage wire corona discharge in higher than that in one stage.

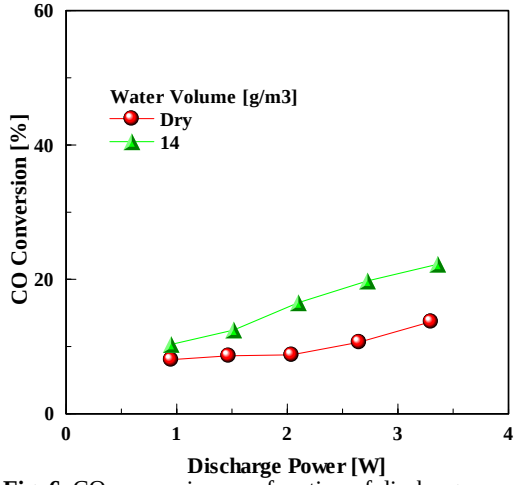

Fig. 6 CO conversion as a function of discharge power (Two-stage wire corona discharge)

2.5 Characteristic of Carbon Monoxide Conversion Efficiency

Carbon monoxide conversion efficiency as a function of Specific Input Energy (SIE) for dry condition or humid condition is shown in Fig. 7. The SIE, which is the ratio of discharge power (P) to the gas flow rate (*Q*), was calculated with the following relations.

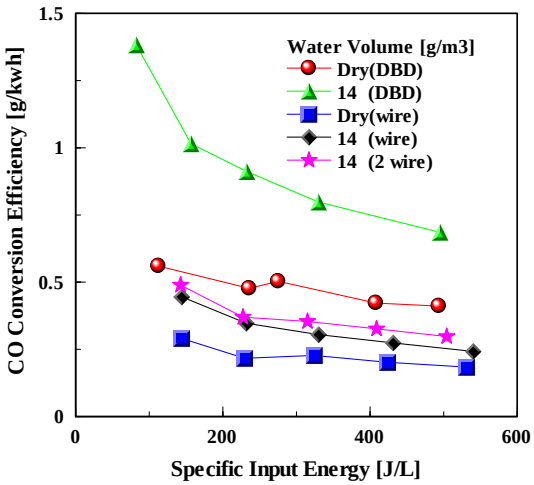

Fig. 7 Carbon monoxide conversion efficiency as a function of SIE

$$\mathrm{SIE} = \frac{P}{Q} \times 60 \qquad [\mathrm{J/L}]$$

where the *Q* is in L/min.

From this characteristic, within any water volume, carbon monoxide conversion efficiency in DBD is higher than in wire corona discharge. It is considered as this reason that DBD generate more uniformly than corona discharge. All things in this work, when dry condition is compared with humid condition in carbon monoxide conversion efficiency, humid condition shows the high value.

3 CONCLUSIONS

In this work, carbon monoxide conversion to carbon dioxide by DBD and corona discharge has been experimentally investigated. The results as follows:

(1) Carbon monoxide was able to be oxidized on each condition.

(2) In DBD and corona discharge, the carbon monoxide conversions are about 50% and 20% at 3.5 W, respectively.

4 REFERENCE

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