Removal of PAHs emitted from diesel engine using an electrostatic precipitator

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1. Introduction

Polycyclic Aromatic Hydrocarbons (PAHs) is one of harmful chemical substances included in diesel emission from ships. PAHs were generated due to incomplete combustion of fuel and lubricating oils. Some PAHs have carcinogenicity, mutagenesis and strong toxicity. Thereby Environmental Protection Agency (EPA) specity for PAHs as a harmful pollutant. There are many reports measuring PAHs concentration in the world. It may be regarded for diesel exhaust gas in the future.

The aim of this study is to remove PAHs in a diesel emission using an electrostatic precipitator.

2. Experimental method

The schematic diagram of the experimental system is shown in Figure 1. The experimental system consisted of a diesel engine (DA-3100SS-IV, Denyo, 5.5 kW), a heat exchanger (HE) and an electrostatic precipitator (ESP). Bunker A (S:0.61 %) was used as a test fuel oil. The HE can cool the exhaust gas from 160 ℃ to 20 ℃ using a refrigerant (city water) of 20 ℃ with a controlled flow rate. The ESP has a parallel plate electrode structure composed of high-voltage application electrode and grounded plate electrode alternately arranged with a gap of 9.5 mm. The high-voltage electrode have saw-tooth edges on their upstream and downstream side, while the grounded electrodes have no such edges.

The high-voltage electrode was supplied with DC voltage of 0 to -9.5 kV to generate corona discharge and collect charged particles. PAHs in the exhaust gas have two phases, which were gasous and particulate matters. The particulate matter is that PAHs attach on the surface of particles, which may be soluble organic fraction (SOF). In this experiment, PAHs concentration attached on particles was measured by drawing a portion of the gas and passing it through a Teflon-coated glass filter to sample PAHs. PAHs on the filter were extracted using a Soxhlet extraction with dichloromethane. PAHs concentration in the extracted solution was measured by a gas chromatograph mass spectrometer (GCMS).

3. Result and Discussion

PAHs concentrations at sampling locations is shown in Figure 2. In this experiment, 4 kinds of PAHs were measured which were Chrysene, Benz[a]anthracene, Benzo[b]fluoranthene and Benzo[a]phrene, because of having strong toxicity. The vertical axis indicates a peak area of the spectrum measured by GCMS, which concern with the concentration. All concentrations on the downstream side of the HE decreased in comparison with the concentration on the upstream side. This is because PAHs may be absorbed into SOF particles generated due to condensation at low temperature. All PAHs concentrations at the downstream side of ESP significantly decreased. This result shows that SOF particles absorbed PAHs are charged and collected by the ESP.

4. Conclusion

The effect of the HE and the ESP on removal of PAHs in the exhaust gas was investigated. Results are follows :

1) PAHs concentration increased due to cooling the gas temperature.
2) Particles included PAHs were removed by the ESP.

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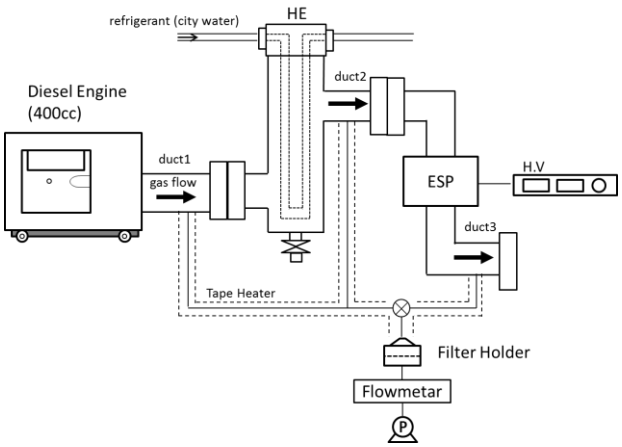

Figure 1. Schematic diagram of experimental system.

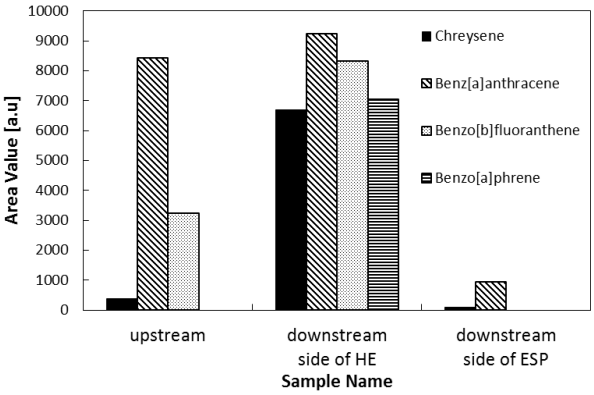

Figure 2. PAHs concentration at locations