New CO_2 Mitigation Process with Diesel Dynamo Power Plant Associated by Optimized Aerosol Driven Technique

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The replacement of current steam power plants to high efficient diesel-combined cycle (DCC) power plants is very practical way for the mitigation of CO_2 emission from power sector; it will be possible to attain 50 million ton/year emission reduction of CO_2, i.e., a half of the target value liable to Japan if the following problem can be overcome.

The high thermal efficiency in DCC is due to its high operation temperature. There additional NO_X emitted (about 5g/kWh)) at high temperature combustion is discharged to the atmosphere, and the development of highly energy effective De-NOx process is the most important to attain the CO_2 mitigation project based on the replacement. In the previous study (Yamamoto, 2010), the De-NO_X efficiency using our Aerosol Driven Technique (ADT) (Azuma, 2008) was 14.4g/kWh, and was insufficient for the target value (20g/kWh; it means 12% reduction of emitted CO_2 from power sector based on current steam power plants) of De-NO_X efficiency. The objective of this research is to fulfil the critical value with the optimization of ADT from the viewpoint of the selection of most effective foreign particle diameter.

The experimental setup for the ADT De-NO_X process was similar to that by Yamamoto (2010); NO_X was converted into NH_4NO_3 with NH_3 radical by the non-thermal plasma technique. Initial NO_X concentration in the reaction chamber was set at 800 ppmv (NO: 80, NO_2: 720). Relative humidity in the chamber was kept more than 95%. O_3 was generated with a corona discharger. NO_X concentration was measured with combustion gas analysers (NO: TSI CA6030, NO_2: TSI CA6040). DOP particles for the ADT were generated with a Rapaport-Weinstock type aerosol generator; the applied diameters of the foreign particles were 0.08, 0.10, 0.12, 0.13, 0.15 and 0.24 μm.

The removal efficiency was the most important parameter for this De-NO_X process, and it was defined as

$$RE_{NO_X} = \frac{dW - dW_{ini}}{E} \times \frac{M_{NO_X}}{M_{AN}} \times \frac{60}{t} \times \frac{Q}{Q_{col}} \qquad (1)$$

where $\mathrm{d}W$ is the collected particles weight by cascade impactor (QCM), $\mathrm{d}W_{\mathrm{ini}}$ is the initial weight of the foreign DOP particles, M_{NOx} and M_{AN} are the molar weights of NOx and NH_4NO_3 respectively, t is the collected time, Q_{col} is the flow rate of the QCM (2.4ℓ/min).

Table 1 shows the NO_X concentration at the outlet of the De-NO_X experimental system with ADT (heterogeneous nucleation of NH_4NO_3 particles) and without ADT (homogeneous one). It showed that the NO_X concentration reduced about 10% installing ADT. **Table 2** and **Fig.1** show the importance of the selection of foreign particle diameter for the removal efficiency of NO_X. Especially, $D_{g,final}$, the final diameter of grown NH_4NO_3 particles generated via homogeneous nucleation, was very small, and the resultant RE_{NOX} became so small comparing to the heterogeneous one.

Table 1 De-NOx efficacy by ADT in this experiment

	Initial C_{NOX} (ppmv)	C_{NOX} (ppmv)
Without ADT	800	257
With ADT	800	166

Table 2 Final particle diameter, collected NH_4NO_3 mass and removal efficiency with and without ADT

Initial D_g (μm)	$D_{g,final}$ (μm)	dW ($\times 10^{-5}$mg/cm^3)	RE_{NOX}
Without ADT	0.08	2.5	4.2
With ADT	0.26	6.9	17.6

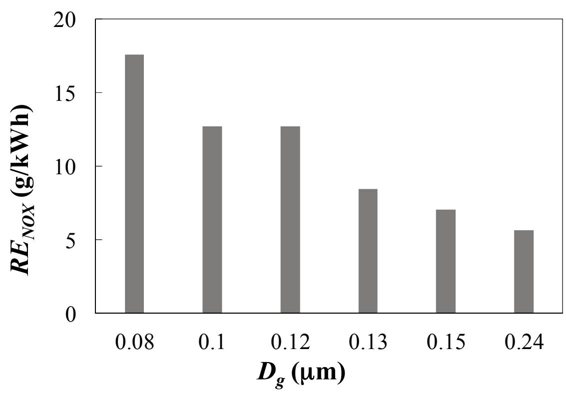

Fig. 1 Relationship between removal efficiency and initial diameter of foreign particles for ADT.

By the optimization of ADT process with most effective foreign particles, the removal efficiency could be revised up to 17.6g/kWh from 14.4g/kWh, and it will not be so difficult to attain the target value (20g/kWh) of this process by further optimization of ADT.

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