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A study on Gas and Solid Phase Distribution of PCDD/Fs of a Diesel Engine with variable Load Rate

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Introduction

Recently, motor vehicles were suspected as a emission source of PCDD/Fs. These studies comprised test bench experiments as well as road tunnel measurements.^{1)~3)}

In this study, PCDD/Fs emissions of diesel engine were investigated, as the load rate was changed from 25% to 75% at constant speed of 2400rpm. Then, the sample was divided into 4 parts in order to analyze for phase distribution.

Experimental

Sampling Site

The engine being tested was manufactured by Hyundai, type D4BB(driven for 31,700km). It has maximum power of 59kW at 4000rpm and maximum torque of 168Nm at 2400rpm. The engine was fueled with normal commercial diesel fuel. Before the experiments, the engine was conditioned for 15 hours at a speed of 3000rpm, with 20% of load rate. The experimental condition varied from 25% to 75% of load rate while running at 2400rpm. The condition was selected by the Emission Test Cycles, US D-13 Mode. According to the mode, the particulate emission of exhaust gas is almost same at the condition of 25%, 50% and 75% load rate at 60% engine speed (2400rpm). Figure 1 shows the US D-13 Mode Cycles and Table 1 represents the experimental condition.

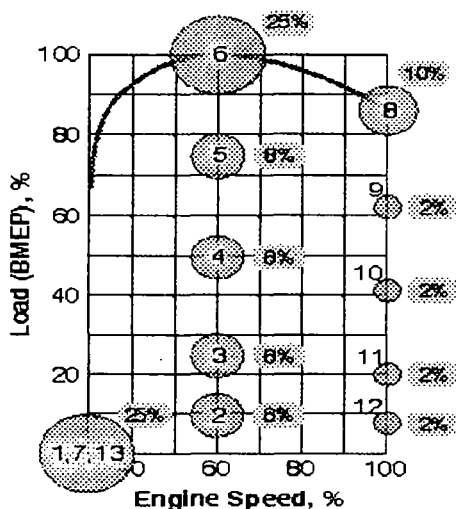


Fig 1. The US D-13 Mode⁴⁾

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Table 1. Experimental Condition

Sample series	Fuel Consumption (Liter/hr)	Sample Collected (Nm ³)	Load rate (%)	Speed (rpm)
A	18.16	2.5725	25	2400
B	29.10	2.7504	50	
C	42.73	3.0631	75	

Measurement of exhaust gas parameters

PCDD/Fs sampling was carried out isokinetically at the port closer to the engine to avoid flow disturbances by the probes for the continuous measurements.

The sample was separated into 4 parts (filter, absorber I, XAD resin, absorber II). Each part was pretreated and analyzed for PCDD/Fs. It was defined that the solid phase is trapped on the filter and the gas phase is passed through the filter⁵. Figure 2 represents PCDD/Fs sampling apparatus.

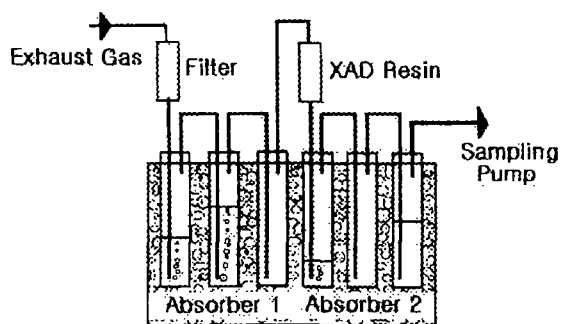


Fig 2. The Sampling Apparatus

PCDD/Fs analysis

Sample extraction and clean-up were carried out in accordance with the Korean Standard Method. Filter and absorbent were Soxhlet extracted separately with toluene for 24 hours. The equipment for sample clean-up comprised a mixed column with differently treated multi-layered silica and alumina column. The analysis was performed on selected ion monitoring mode with a JEOL JMS-700 high resolution mass spectrometer connected with a high resolution gas chromatography.

Results and Discussion

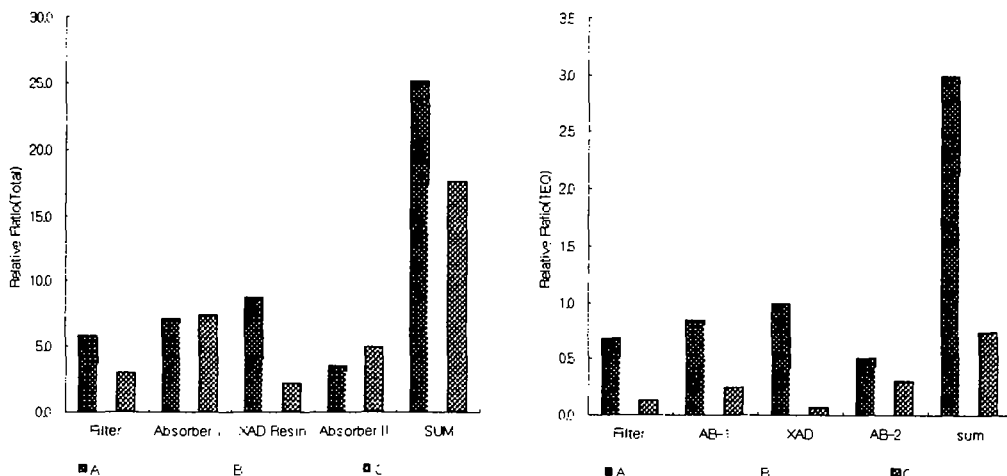
Diesel engine emission measurements were carried out at a constant speed, 2400rpm with variable load rate from 25% to 75%. The 2,3,7,8-substituted PCDD/Fs total and TEQ concentration of each sample with units of pg/Nm³ (exhaust gas) are shown in Table 2.

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Table 2. The concentrations of PCDD/Fs of diesel engine

Sample series		PCDD/Fs Concentration				Sum
		Filter (Solid Phase)	Absorber I	XAD Resin	Absorber II	
Total (pg/Nm ³)	A	57.88	71.08	87.44	34.51	250.91
			193.03			
	B	36.20	67.08	39.60	29.03	171.91
			135.71			
	C	29.39	73.97	21.84	49.47	174.67
			145.29			
TEQ (pg-TEQ/Nm ³)	A	6.72	8.31	9.86	5.00	29.88
			23.16			
	B	5.06	7.88	3.99	4.17	21.10
			16.04			
	C	1.23	2.37	0.68	3.03	7.30
			6.07			

The 2,3,7,8-substituted PCDD/Fs concentrations of Filter and XAD resin were decreased, as the load rate was increased. However, the concentrations of Absorber I and Absorber II were almost the same.



(a) Distribution of total concentration

(a) Distribution of TEQ concentration

Fig 3. PCDD/Fs Concentration of Exhaust Gas Sample

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The solid phase : gas phase ratios were 23:77, 21:79 and 17:83 at 25%, 50% and 75% of load rate, respectively. As the load rate was increased, the ratio of solid phase PCDD/Fs concentration was slightly decreased. The ratio of concentrations of Absorber I and Absorber II were increased but the XAD Resin ratio showed a decrease.

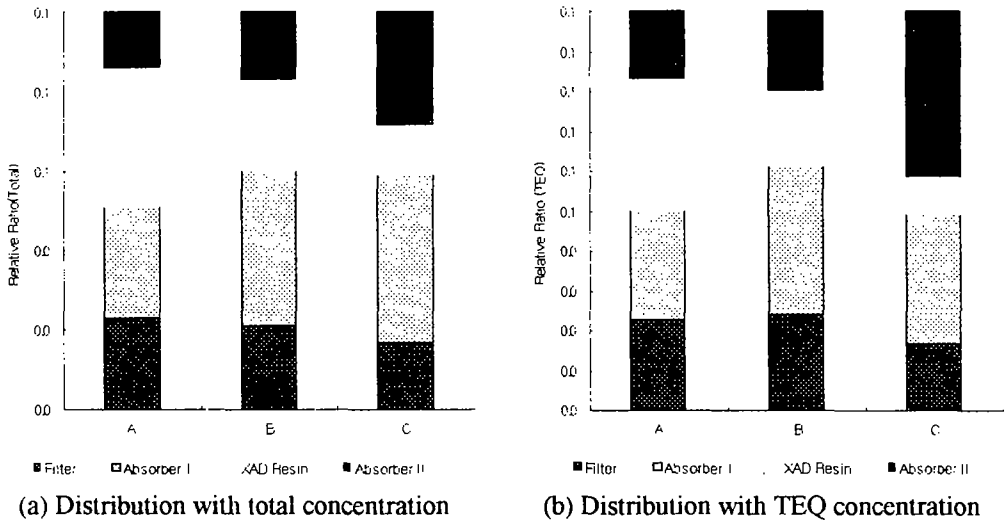


Fig 4. Relative Ratio of Exhaust Gas Sample for Phase Distribution

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