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A STUDY ON PCDD/Fs EMISSION CHARACTERISTICS OF A DIESEL ENGINE WITH VARIABLE LOAD RATE

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Introduction

A significant number of studies are available about sources, toxicity and formation mechanism of PCDD/Fs in municipal solid waste incinerator (MSWI). Although PCDD/Fs are mainly emitted from MSWI, several studies have indicated that vehicle exhaust is also a PCDD/Fs source. These studies were comprised in test bench experiments as well as road tunnel measurements.¹⁾⁻⁵⁾

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 2400 rpm.

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. The average fuel consumption was 299g/kWh during the experiments. Before the experiments, engine lube oils, oil filter, fuel filter and air cleaner were changed and 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 stationary speed, 2400rpm. Table 1 represents the experimental condition.

Table 1. Experimental Condition

Sample series	Fuel Consumption (Liter/hr)	Sample Collected (Nm ³)	Load rate (%)	Speed (rpm)
25% - 1	18.16	2.573	25	2400
50% - 1	29.10	2.750	50	
75% - 1	42.73	3.063	75	
25% - 2	18.12	2.584	25	
50% - 2	29.20	2.648	50	
75% - 2	42.46	2.987	75	

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Measurement of exhaust gas parameters

Flue gas velocity was measured with an anemometer. The water content of the diesel exhaust gas was determined gravimetrically after absorption with calcium chloride. The following parameters were measured continuously : oxygen, carbon monoxide, total hydrocarbon, nitrogen oxides and particulate matter. 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.

PCDD/Fs analysis

Sample extraction and clean-up were carried out in accordance with Korean Standard Method. Filter and absorbent were Soxhlet extracted 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 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 total and TEQ PCDD/Fs concentration of each sample with units of pg/L (fuel) and pg/Nm³ (exhaust gas) are shown in Table 2.

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

Sample series	PCDD/Fs Concentration (units of Fuel)		PCDD/Fs Concentration (units of Exhaust Gas)	
	pg/L	pg TEQ/L	pg/Nm ³	pg TEQ/Nm ³
25% - 1	29.70	1.321	209.73	9.356
50% - 1	11.02	0.612	116.73	6.495
75% - 1	9.48	0.399	132.35	5.591
25% - 2	29.83	2.774	209.51	19.607
50% - 2	8.43	0.662	93.05	7.308
75% - 2	8.38	0.507	119.37	7.214

The average PCDD/Fs concentrations per units of exhaust gas with 25%, 50% and 75% of load rate were 209.6, 104.9 and 125.9 pg/Nm³, respectively. The total PCDD/Fs yield from 25% of load rate were about twice higher than 50% or 75% of it. As a load rate was increased, the PCDD/Fs concentration was slightly decreased.

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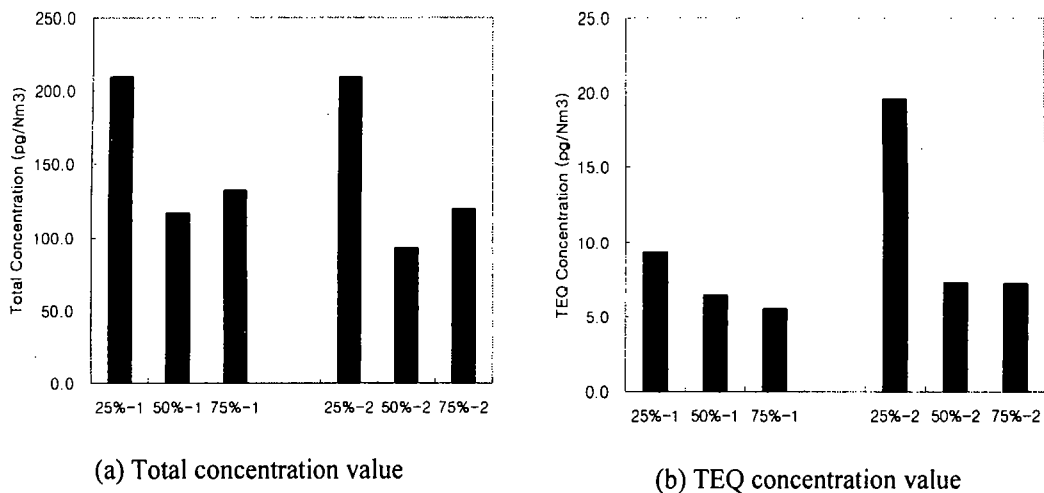


Fig 1. PCDD/Fs Concentration of Exhaust Gas

The diesel engine emitted a large amount of highly chlorinated (hepta and octa) PCDD/Fs congeners, especially OCDD, 1,2,3,4,6,7,8-HpCDF, OCDF. As a view of TEQ concentration, 2,3,4,7,8-PeCDF was predominant isomer. The PCDD/Fs isomer patterns are shown Figure 2.

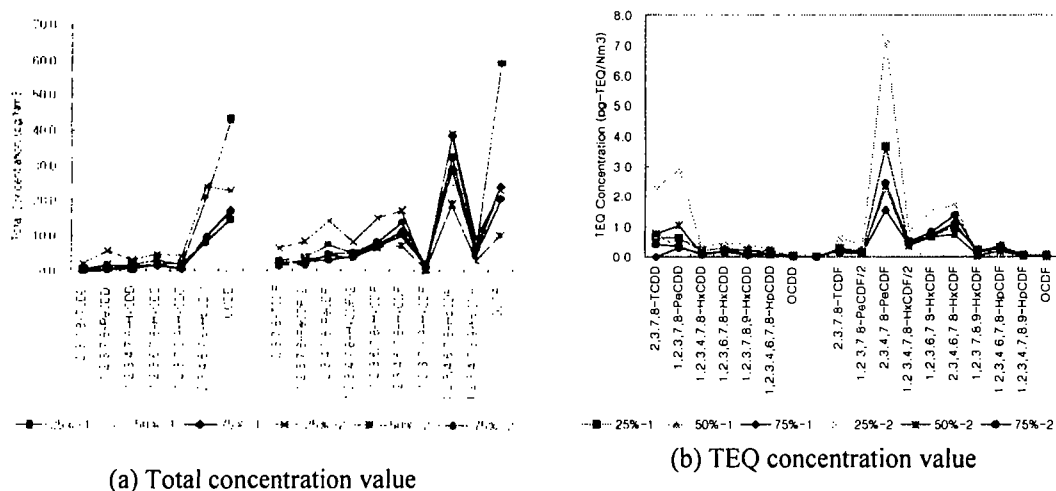


Fig 2. The Isomer Pattern of Exhaust Gas

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When load rates were 25%, 50% and 75%, the average ratios of PCDD:PCDFs were 33:67, 32:68 and 23:77, respectively (Fig. 3). As a load rate was increased, the ratio of PCDDs was gradually decreased.

In terms of chlorination, the average ratios of low chlorinated versus high chlorinated PCDD/Fs were 33:67, 35:65, 32:68, respectively.

So, the amount of PCDFs and high chlorinated PCDD/Fs were larger than PCDDs and low chlorinated PCDD/Fs from exhaust gas of diesel engine.

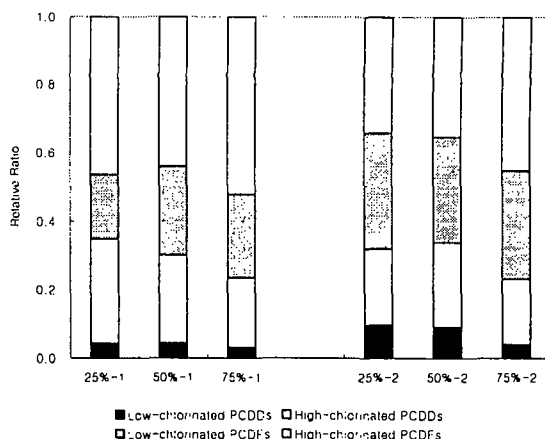


Fig 3. The Relative Ratio of PCDDs : PCDFs

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