CHAPTER IV

RESULT AND DISCUSSION

Identification of PAHs in Diesel Exhaust

PAHs were identified and quantified by GC-MS. The data from GC-MS were collected by Masslab solfware running on a personal computer. The computer software associated with the MS allows the output of the total ion chromatogram and background subtraction to yield mass spectra that are of individual peaks, or can take an advantage of the SIM technique. Identification of individual peak was performed by comparison the mass spectra with the electronic libraly based on the Nation Bureau of Standard Library (NIST). The study of GC chromatograms of standards and samples are shown in appendices A-B. In this study, standard PAHs from EPA 610 containing naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluorantene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k] fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, dibenzo[a,h]anthracene and benzo[g,h,i]perylene, were used. They were used as the standard for establishing the calibration curve for quatify of each PAH by comparing the peak area of each ion chromatogram to the calibration curve. The retention times and detection limits of the individaul PAHs are shown in Table 4.1.

Table 4.1 Molecular weight, retention time and detection limits of standard PAHs

PAHs	MW.	Retention time (min)	Detection limits (ppm)
Naphthalene	128	4.604	0.25
Acenaphthylene	152	6.662	0.25
Acenaphthene	154	7.013	0.25
Fluorene	166	8.145	0.25
Phenanthrene	178	10.988	0.25
Anthracene	178	11.155	0.25
Fluoranthene	202	14.905	0.25
Pyrene	202	15.546	0.25
Benz[a]antracene	228	21.117	0.5
Chrysene	228	21.210	1.00
Benzo[b]fluoranthene	252	25.150	nd
Benzo[k]fluoranthene	252	25.063	nd
Benzo[a]pyrene	252	26.163	1.00
Indeo[1,2,3-cd]pyrene	276	29.195	2.00
Dibenzo[z,h]anthracene	278	29.296	2.00
Benzo[ghi]perylene	276	29.609	1.00

nd: not determind

Appendix B shows that the emission consisted of different levels of naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene and pyrene. The repeatability of analytical method are shown in Table 4.2.

Table 4.2 Repeatability of analytical method.

PAHS	Repeatability		SD
	1	2	
Naphthalene	2.087	2.587	0.25
Acenaphthylene	1.941	2.363	0.211
Acenaphthene	2.135	2.327	0.096
Fluorene	2.749	2.383	0.183
Phenanthrene	2.097	2.691	0.297
Anthracene	3.426	2.290	0.568
Fluoranthene	4.011	3.069	0.471
Pyrene	2.85	1.734	0.558

The results in Table 4.2 show the good precision of the analytical method of this study. The PAHs with molecular weight higher than pyrene may be found at low levels. In this study, these polycyclic aromatic compound could not be detected because their concentration was lower than the detection limit.

Properties of Diesel Fuel

Five blended fuels were used in the test, base fuel without oxygenated additive, base fuel with 4,6,8 and 10 % by volume isoamyl alcohol. Table 4.3 shows the properties of these blended fuel, tested according to the ASTM standard method. It shows the different flash point and distillation point in experiment.

Table 4.3 Properties of base fuel diesel and base fuel blended isoamyl alcohol.

TEST ITEMS	ASTM D	LIMITS	Oxygenated Concentration. (vol %)				
			0	4	6	8	10
API Gravity @ 60 °F	1298	report	37.1	37.5	37.6	37.7	37.9
Specific Gravity @ 60/60 °F	1298	0.81-0.87	0.8393	0.8373	0.8368	0.8363	0.8353
Calculated Cetane Index	976	47 min	52	52	52	52	52
Flash point, (P.M.), °C	93	52 min	65	49	48	46	45
Distillation, °C	86						
IBP		report	172	132.5	131.6	129.8	129.3
10% recovered		report	203.2	188.2	177.7	161.0	149.9
50% recovered		report	274.1	270.5	270.3	266.8	265.6
90% recovered		357 max	348.3	346.4	347.7	344.2	344.1

Various Effects on Exhaust Emission

In the combustion process, more than 99% of fuel-related PAHs is decomposed. In the diesel exhaust, the ratio of uncompleted fuel related to the sum of PAHs varies from about 1% to 80% depending on the fuel and engine condition. However, the combustion effciency of a PAH is related to a number of factors in the combustion chamber, e.g. temperature, oxygen concentration, swirl, and kinetics of PAH reactions[7,16,20]. The goal of this study is to investigate the effect of isoamyl alcohol on the combustion efficiency of PAHs in diesel exhaust.

Isoamyl alcohol was selected for this study to decrease PAHs in diesel exhaust because it is a by-product of carbohydrate fermentations, low cost and high solubility when blend with diesel fuel.

The blended fuel was chosen to find the suitable condition of engine speed and oxygenated additive by investigation of PAHs in exhaust emission. Engine speed and concentration of isoamyl alcohol were varied. Results, such as effect of speed of the engine and effect of concentration of isoamyl alcohol on the PAHs in exhaust emission are reported and discussed here.

Effect of Engine Speed on PAHs in Diesel Exhaust

In studying of the effect of engine speed on exhaust emission, engine speed was varied between 800, 1600 and 2400 rpm. The concentration of individaul PAH in diesel exhaust was shown in Table 4.4.

The data in Table 4.4 are plotted to show the relationship between engine speed and the concentration of the individaul PAH in exhaust from base diesel fuel in Figure 4.1.

Table 4.4 Concentration of the individaul PAH in base diesel fuel exhaust at 800, 1600 and 2400 rpm.

PAHs	Concentration of PAHs (μg/m^3)		
	800 rpm.	1600 rpm.	2400 rpm.
Naphthalene	4.931	4.206	4.565
Acenaphthylene	2.337	2.195	2.308
Acenaphthene	2.152	2.203	2.160
Fluorene	2.231	2.141	2.150
Phenanthrene	2.566	2.063	2.271
Anthracene	2.394	2.110	2.372
Fluoranthene	2.858	2.184	2.220
Pyrene	3.540	2.212	2.204

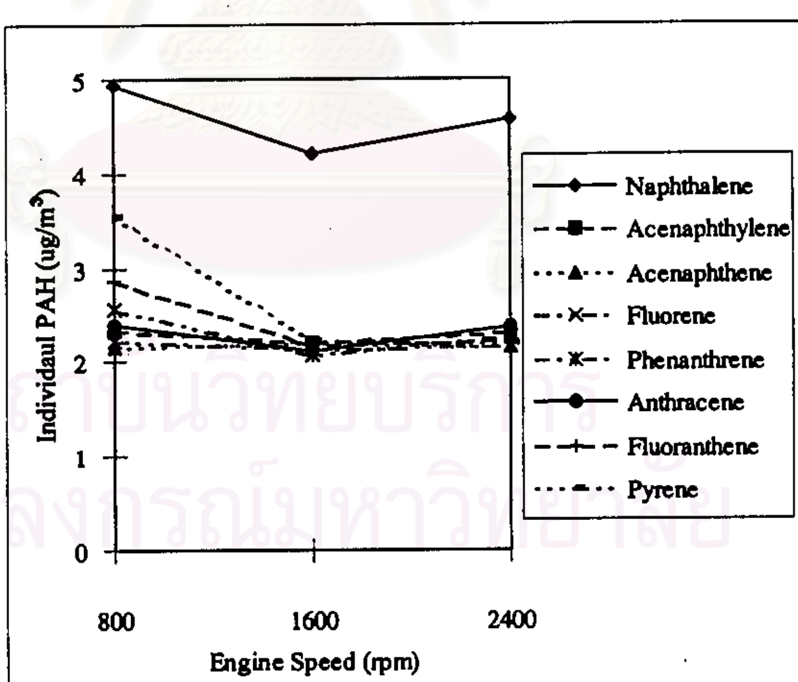

Figure 4.1 Concentration of the the individaul PAH (μg/m^3) in base diesel exhaust at different engine speed.

Engine speed affects the swirl characteristics, injection timing and combustion temperature of the engine. At low speed there is less swirl and a lower combustion chamber temperature. At mid-speed the optimum swirl dynamics and optimum combustion timing develop the maximum power band for the Prima engine. High engine speeds over-swirl and shortens the period over which combustion proceeds. The effect of increase of engine speed might be explained in terms of different rate of combustion of the PAH : increased speed limits the combustion reaction, allowing sufficient time for some PAH to react but not for others [16].

Figure 4.1 shows that the concentration of naphthalene, Acenaphthylene, Acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene and pyrene decreased when engine speed was changed from 800 rpm to 1600 rpm and increased at 2400 rpm. At 800 rpm, low combustion chamber temperatures and less swirl leads to the PAHs content increase, due to the high resistance to the oxidative attack. At an engine speed of 1600 rpm, the concentration of individual PAHs in base diesel exhaust was lower than at 800 rpm because of the higher combustion temperature. On the other hand, the PAHs content increased at 2400 rpm because of over- swirl and short time leading to uncombusted PAHs. The optimum speed for combustion efficiencies are greatest at 1600 rpm. The lowest engine speed, 800 rpm, has the greatest environmental effect. Vehicles in traffic jams are operated at low engine speeds and, hence, emit high PAH concentrations.

Effect of concentration of isoamyl alcohol on exhaust emission

In studying of effect of isoamyl alcohol on exhaust emission, the engine speed was fixed at 800,1600 and 2400 rpm and isoamyl alcohol was varied to be 4,6,8 and 10 % by volume. The concentration of individual PAH in the exhaust gas was analyzed. The results are shown in Figures 4.2-4.9.

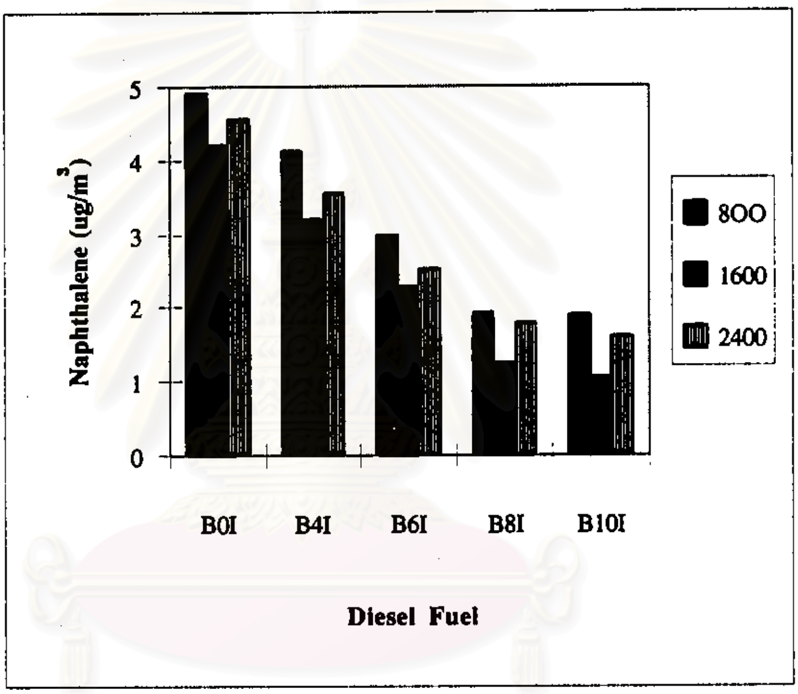

Figure 4.2 The effect of isoamyl alcohol on naphthalene in Diesel exhaust at different engine speed

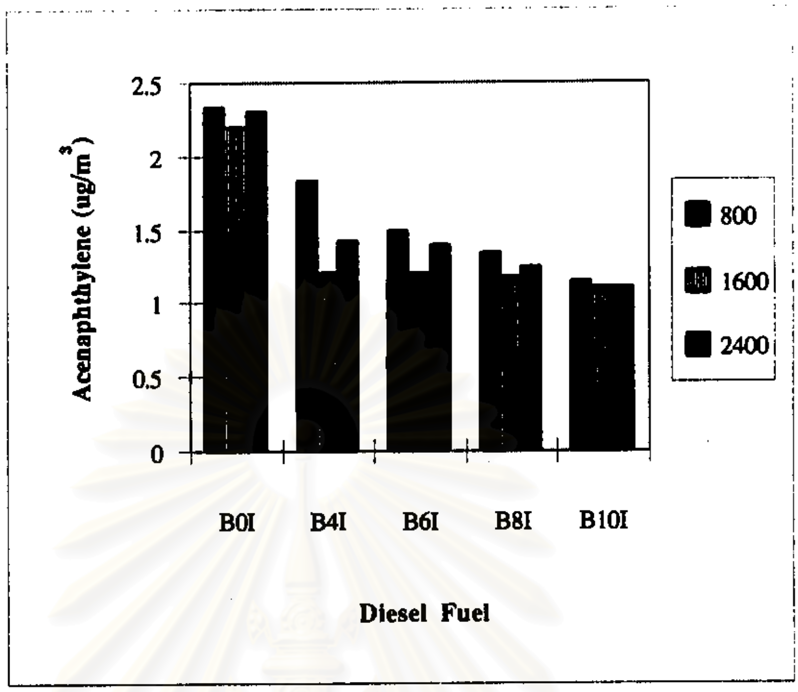

Figure 4.3 The effect of isoamyl alcohol on acenaphthylene in Diesel exhaust at different engine speed

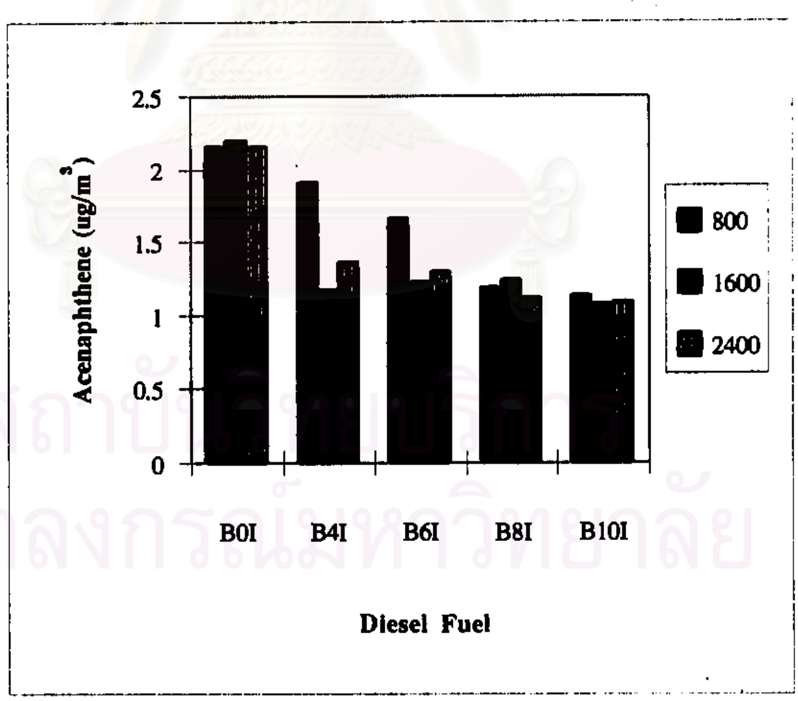

Figure 4.4 The effect of isoamyl alcohol on acenaphthene in Diesel exhaust at different engine speed

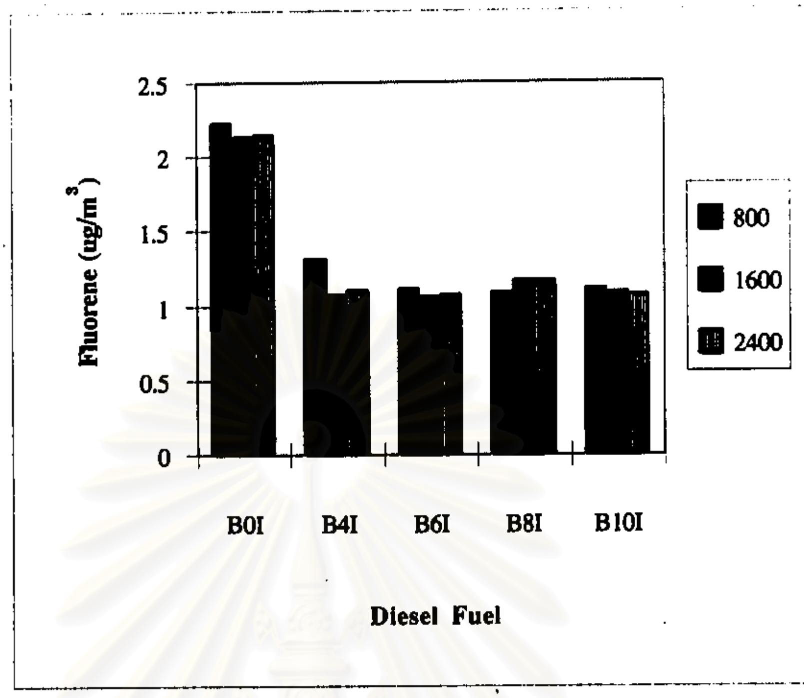

Figure 4.5 The effect of isoamyl alcohol on fluorene in Diesel exhaust at different engine speed

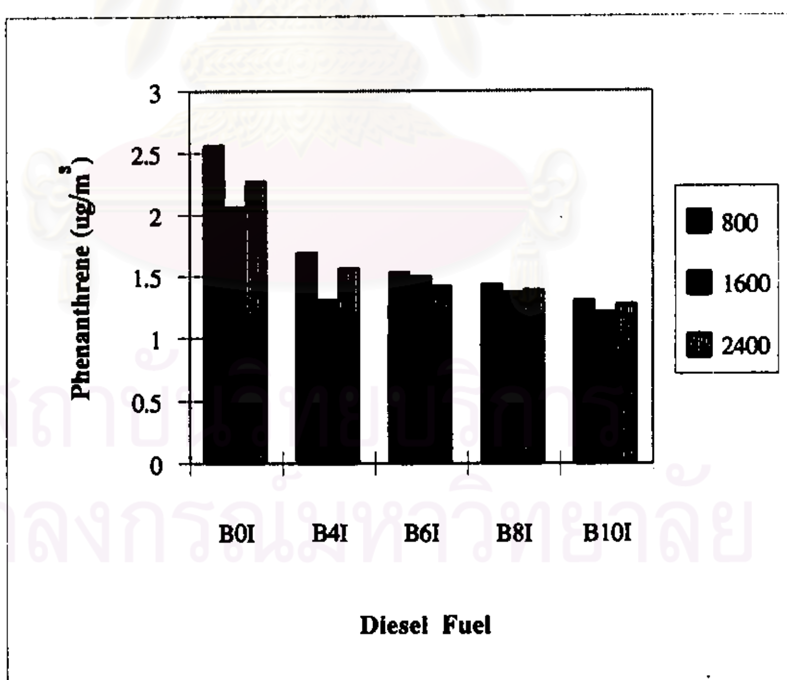

Figure 4.6 The effect of isoamyl alcohol on phenanthrene in Diesel exhaust at different engine speed

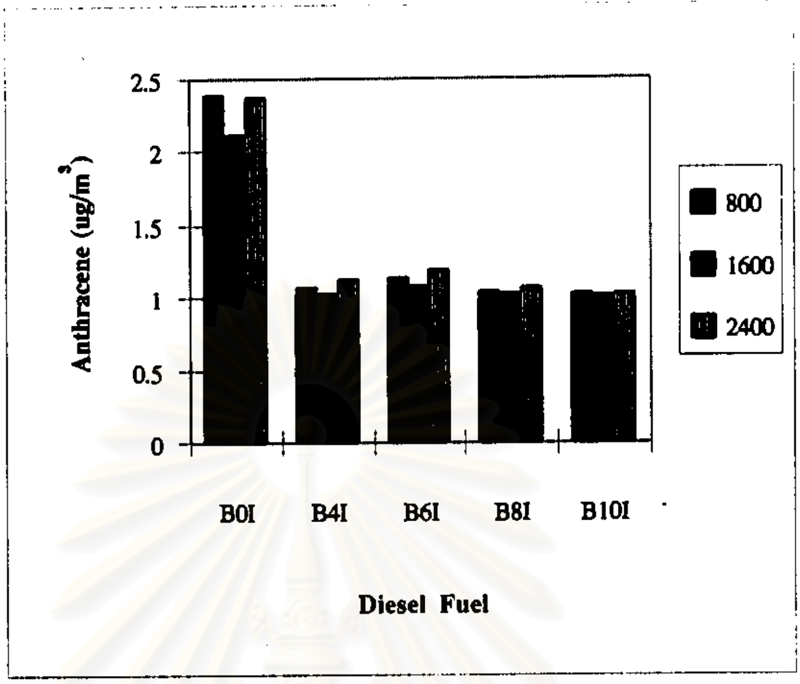

Figure 4.7 The effect of isoamyl alcohol on anthracene in Diesel exhaust at different engine speed

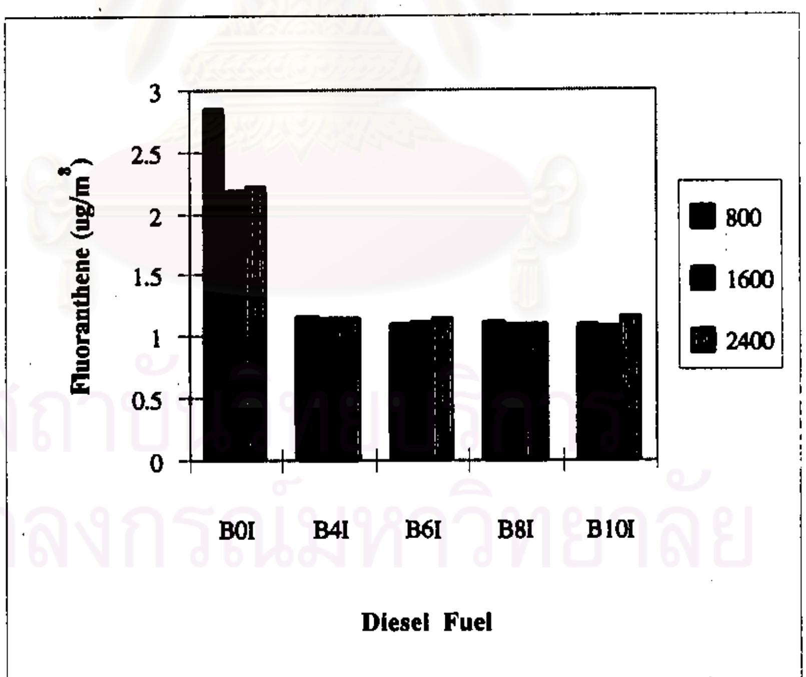

Figure 4.8 The effect of isoamyl alcohol on fluoranthene in Diesel exhaust at different engine speed

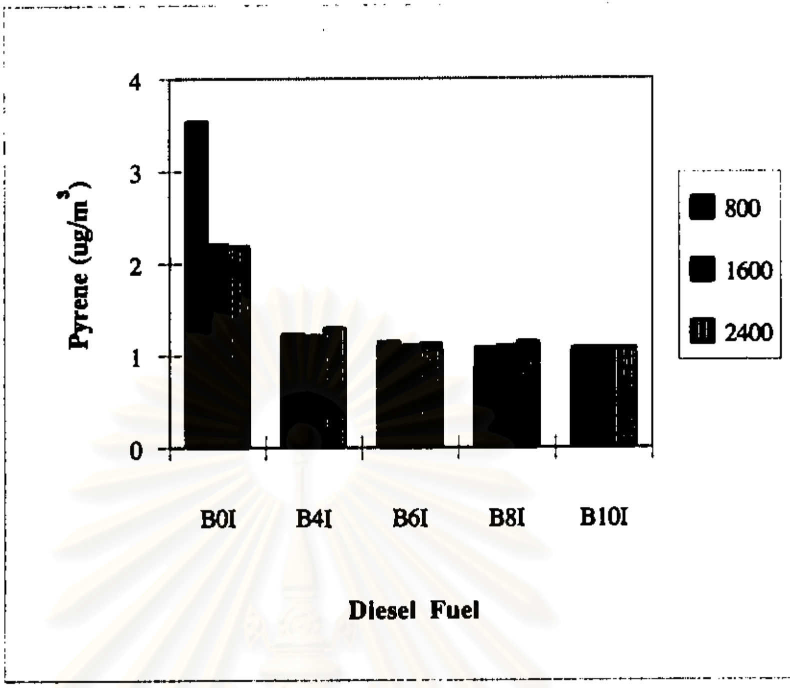

Figure 4.9 The effect of isoamyl alcohol on pyrene in Diesel exhaust at different engine speed

Histograms in Figures 4.2-4.9 show that when isoamyl alcohol was added to base diesel fuel, PAH levels in the exhaust were reduced. The concentration of naphthalene, aceanphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene and pyrene were significantly decreased with increasing concentration of isoamyl alcohol.

The concentration of total PAHs in the exhaust gas was analyzed. The results are shown in Table 4.5.

Table 4.5 Effect of concentration of isoamyl alcohol on total PAHs in exhaust emission at 800, 1600 and 2400 rpm.

Concentration of isoamyl alcohol (% Vol)	Concentration of total PAHs (μg/m^3)		
	800 rpm.	1600 rpm.	2400 rpm.
0	23.009	19.314	20.250
4	14.371	11.407	12.616
6	12.202	10.601	11.196
8	10.198	9.482	10.031
10	9.825	8.743	9.445

The data in Table 4.5 were plotted to shown the relationship between concentration of isoamyl alcohol and engine speed with concentration of total PAHs (Figure 4.10).

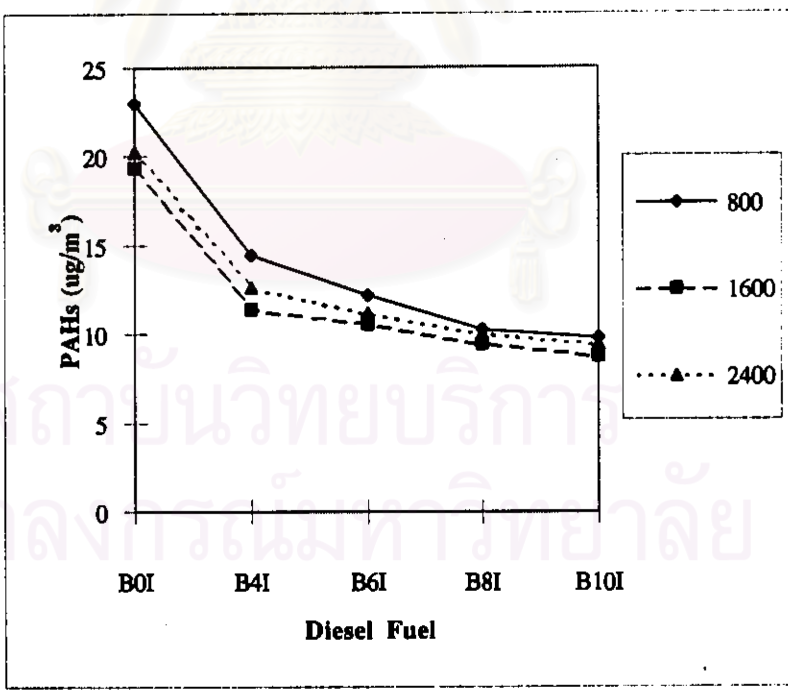

Figure 4.10 Effect of concentration of isoamyl alcohol on total PAHs in exhaust emission at different engine speed.

The total PAHs in diesel exhaust emission decreased when isoamyl alcohol was added to base diesel fuel. All of the blended fuels had lower PAHs emission than the untreated fuel and the lowest was with 10 % by volume of isoamyl alcohol. These results clearly show that the decrease in PAHs emission are directly related to the isoamyl alcohol concentration. Addition of alcohol into the base diesel fuel, leads to increased oxygen content because the alcohols include oxygen in their chemical structure, and less air is required for complete combustion.