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A STUDY OF REDUCTION FOR COMBUSTION PRODUCTS OF A GASOLINE ENGINE – ESPECIALLY EFFECTS OF MULTI COMPONENT FUEL PROPERTIES

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Abstract

It is well known that the component proportion of gasoline varies depending on the extraction time of crude oil and the production country. Of course, there are effects of the engine performance and the emission on a little. So it is necessary to examine the effects of multi component fuel on the combustion characteristics and emissions. This study aims to examine the effects of fuel composition on the fuel properties and emission characteristics (HC, CO, NOx, etc.) by using multi component fuels in a small gasoline engine. Multi component fuels (model fuel) mixed with plural hydrocarbon compounds was used as fuel. The two kinds of main component fuel were used for the test base fuel (50 vol% Iso-Octane and 25-vol% Toluene). The other addition fuels were selected pure fuel (10 kinds of fuel: Iso-Octane, Toluene, Pentane, Hexane, Heptane, Octane, Di-Isobutylene, Methyl cyclohexane, P-Xylene, Ethanol), it was mixed 25 -vol% in the base fuel. The main conclusions are as follows, 1) The HC emissions decrease with increasing the evaporation velocity of addition fuels for normal chain paraffin. 2) The CO emissions monotonically decrease with increasing excess air ratio by using multi component fuels. 3) It is possible to control the HC, CO and NOx emissions by using the fuel of 25-vol% ethanol addition for a small gasoline engine.

Keywords: *combustion products, gasoline engine, multi component fuel*

1. Introduction

In recent year, multi component fuels have attracted attention as an environmentally substitute fuel because of exhaustion of petroleum resources and environmental issues. Of course, global environmental problems and global energy saving problems became very serious. Naturally, internal combustion engines are main causes of these have problems. So it is necessary environmentally substitute fuel to achieve low emissions and low fuel consumption for internal combustion engines. Especially, in automotive gasoline engines, low HC, CO and NO_x emissions are very much needed by using multi component fuels. Unfortunately, it is well known that the multi component fuels are effects on the fuel properties and emission characteristics for an internal combustion engine. Over the past few decades, a considerable number of studies have been conducted on these problems from the multiple points. For example, several techniques were developed for reduction of HC, CO and NO_x emissions from the gasoline and diesel engines such as EGR (Exhaust gas recirculation), lean combustion, HCCI (Homogeneous Charge Compression Ignition), blended fuels and new injection system [1-13]. However, very few attempts have been made at the wide multi component fuel by using the small gasoline engines.

As the first step in this study, experiments have been carried out to examine the effects of fuel composition on the fuel properties and emission characteristics of a small gasoline engines by using multi component fuels. Multi component fuels (model fuel) mixed with plural hydrocarbon compounds was used as fuel. The two kinds of main component fuel were used for the test base fuel (50-vol% Iso-Octane and 25-vol% Toluene). The other addition fuels were selected pure fuel (10 kinds of fuel: Iso-Octane, Toluene, Pentane, Hexane, Heptane, Octane, Di-Isobutylene, Methyl cyclohexane, P-Xylene, Ethanol), it was mixed 25-vol% in the base fuel.

2. Experimental Apparatus and Procedure

Figure 1 shows the experimental set up employed in this study. It consists of a small gasoline engine (KIPOR, KGE3.5:277cc 4 stroke) and an analyser of exhaust gas (AVL Di COM 4000: NOx: Chemiluminesence, CO and CO2: NDIR, O_2: Zirconia).

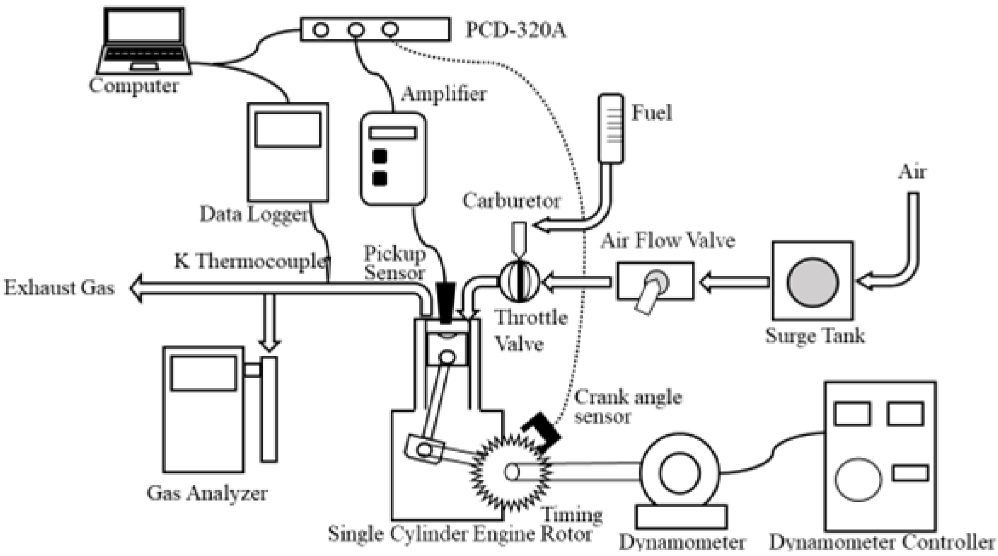

Fig. 1. Block diagram of experimental apparatus

Table 1 shows the engine specifications of the gasoline engine in this study.

Tab. 1. Engine specification

Engine type	4-stroke cycle gasoline engine
Ignition system	T.C.I
Cooling system	Air-cooling
Number of cylinder	1
Bore*Stroke	78mm*80mm
Displacement	277cc
Valve system	OHV
Compression ratio	8.5
Maximum output	3.0kW/3000rpm

Table 2 shows the fuel properties and Tab. 3, 4 show the H/C ratio and evaporation rate for model fuels, respectively. The evaporation rate is calculated by the evaporation time from fuel drop to finished evaporation by using electric balance (METTLER TOLEDO:XP205). The volume of drop fuel is 20 ml in this study.

Tab. 2. Fuel properties

Fuel Properties	Pentane	Hexane	Heptane	Octane	Di-Isobutylene	Methyl-cyclohexane	Toluene	Ethanol
Composition	C_5H_{12}	C_6H_{14}	C_7H_{16}	C_8H_{18}	C_8H_{16}	C_7H_{14}	C_7H_{14}	C_2H_6O
L.H.V [MJ/kg]	48.3	47.9	44.6	44.4	44.0	43.4	40.5	26.8
L.H.V [MJ/kg] Model Fuel (25% volume fraction)	43.3	43.3	43.2	43.2	43.1	43.0	40.5	38.7

Tab. 3. H/C ratio of model fuels

Symbol	H/C Ratio (mole)	Symbol	H/C Ratio (mole)
ISO	2.250	HEP25	1.912
TOL	1.143	OCT25	1.906
DI	2.000	DI25	1.850
ISO25	1.905	MET25	1.852
TOL25	1.612	XYL25	1.645
PEN25	1.928	ETH25	2.015
HEX25	1.919	BASE	1.802

*Base Fuel (50-vol% Iso-Octane and 25-vol% Toluene)

Tab. 4. Evaporation rate (initial)

Symbol	Evaporation rate (Initial: mg/s)
ISO25	0.580
TOL25	0.488
PEN25	1.330
HEX25	0.868
HEP25	0.551
OCT25	0.426
DI25	0.564
MET25	0.530
XYL25	0.432
ETH25	0.806

3. Results and discussion

Figure 2 and 3 show the HC emissions against excess air ratio as a function of additional fuel without the engine load for the small gasoline engine. The additional fuel volume fraction is 25-vol% (constant). The HC emissions are nearly constant under excess air ratio from 0.2 to 0.6 at any additional fuels. On the other hand, over the excess air ratio of 0.8, additional fuel properties strong effects on the HC emissions. It is due to the influence of the evaporation rate and lower heating value of additional fuels.

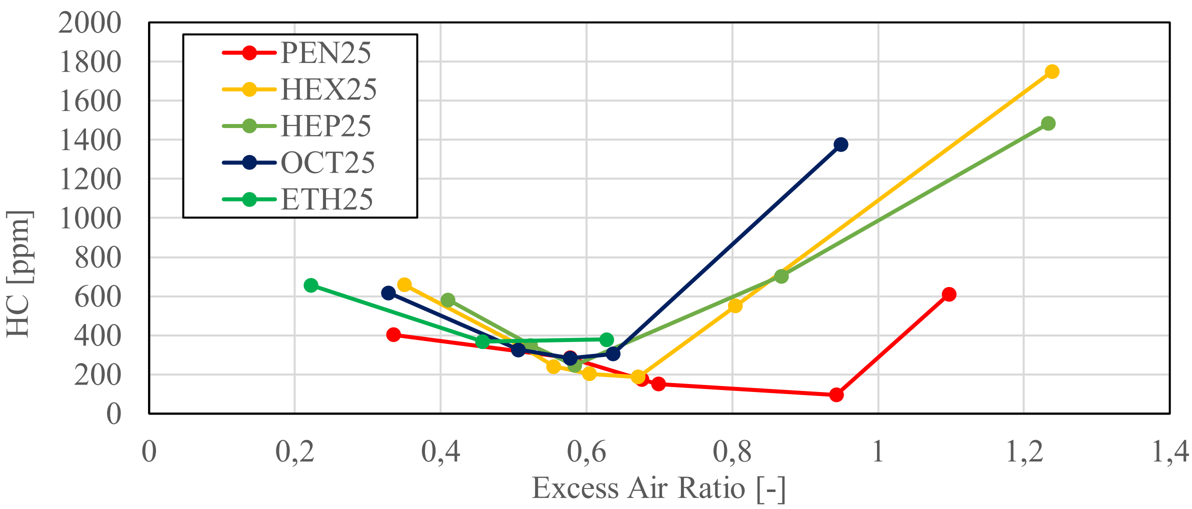

Fig. 2. HC emission (PEN25, HEX25, HEP25, OCT25, ETH25)

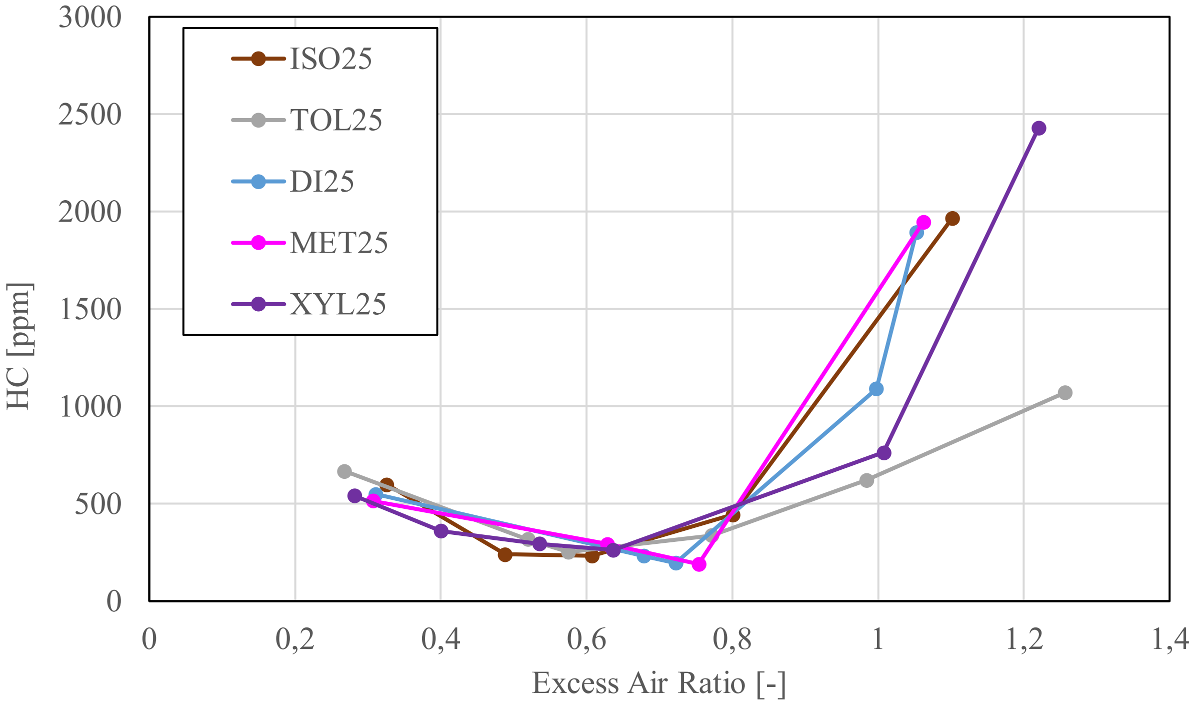

Fig. 3. HC emission (ISO25, TOL25, DI25, MET25, XYL25)

Figure 4 and 5 show the CO emissions against the excess air ratio as a function of additional fuel without and with low engine load for the small gasoline engine. As can be seen from these figures, CO emissions for all the additional fuels are almost same level at same excess ratio. Furthermore, the decreasing ratio from 10 to 0.5 vol% for CO emissions are depend on the additional fuel properties. These results indicated that, the changing of 25-vol% fuel addition can be control the decreasing ratio of CO emissions near the 0.8 excess air ratio for small gasoline engines.

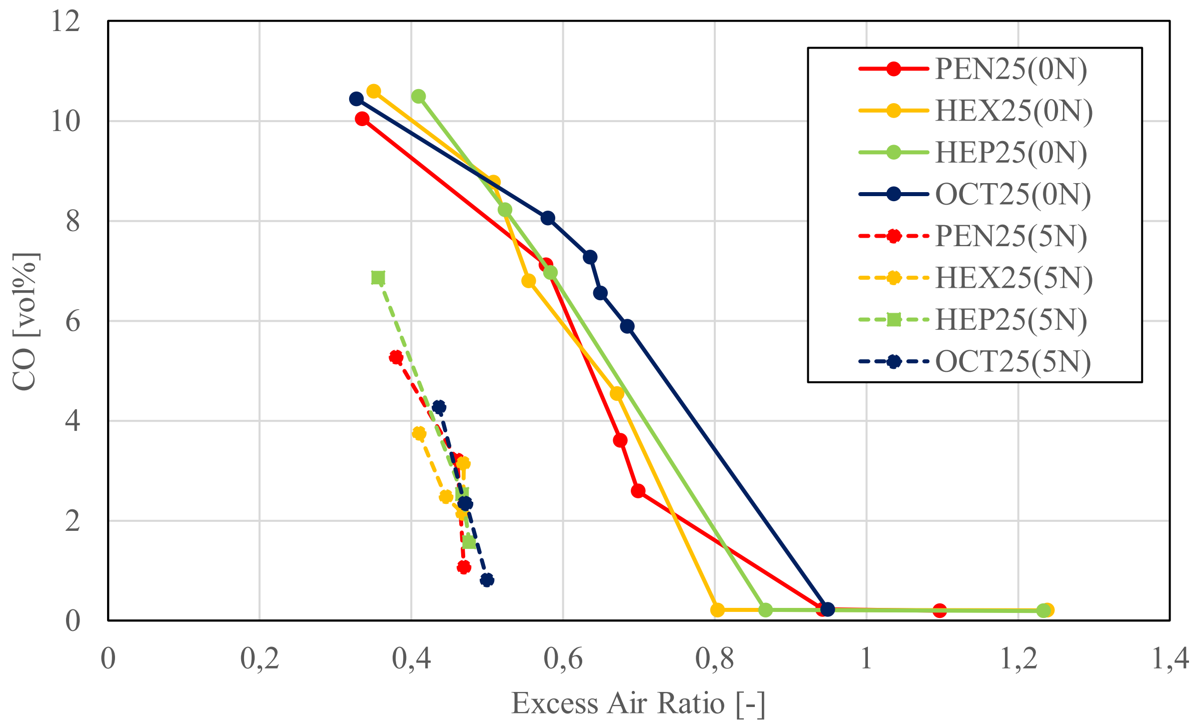

Fig. 4. CO emission (PEN25, HEX25, HEP25, OCT25)

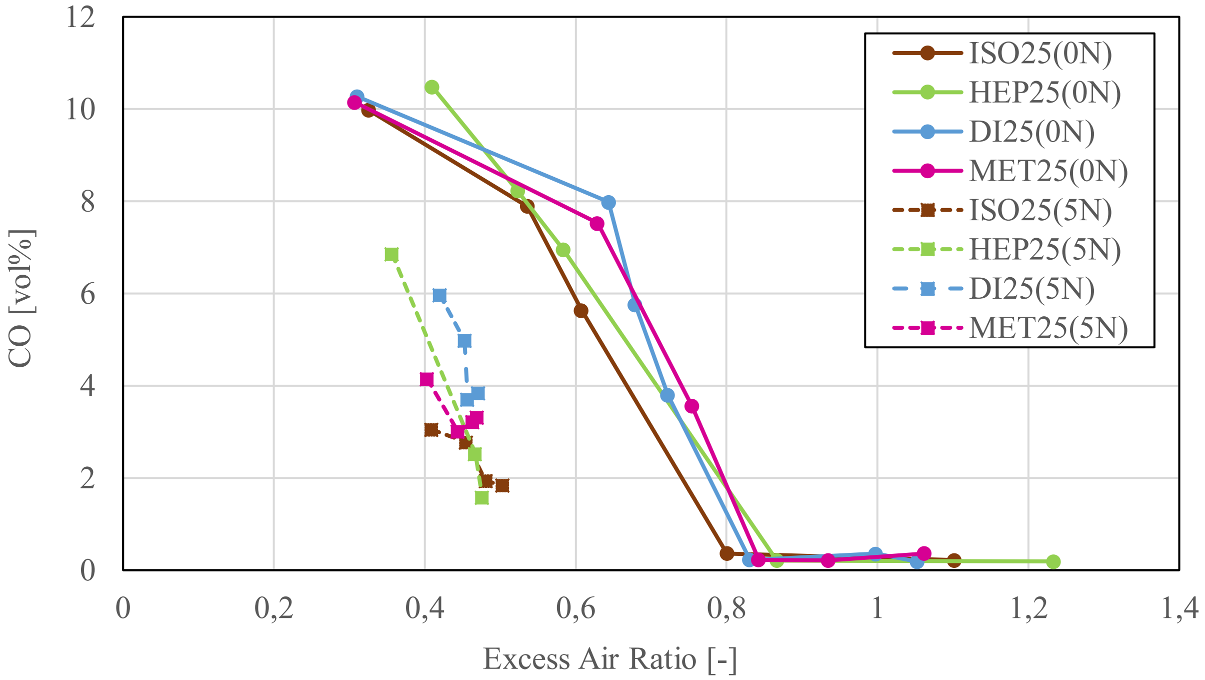

Fig. 5. CO emission (ISO25, OL25, DI25, MET25)

Figure 6 shows the HC emissions against fuel properties as a function of the engine revolution without engine load at constant throttle opening (20%). As seen from this figure, the HC emissions decrease with increasing the engine revolution without ISO and TOL fuel addition. Furthermore, the amount of the HC emissions of ethanol is smaller than that of the other fuel additions without the TOL. It is causes by the effects of the included oxygen for ethanol addition.

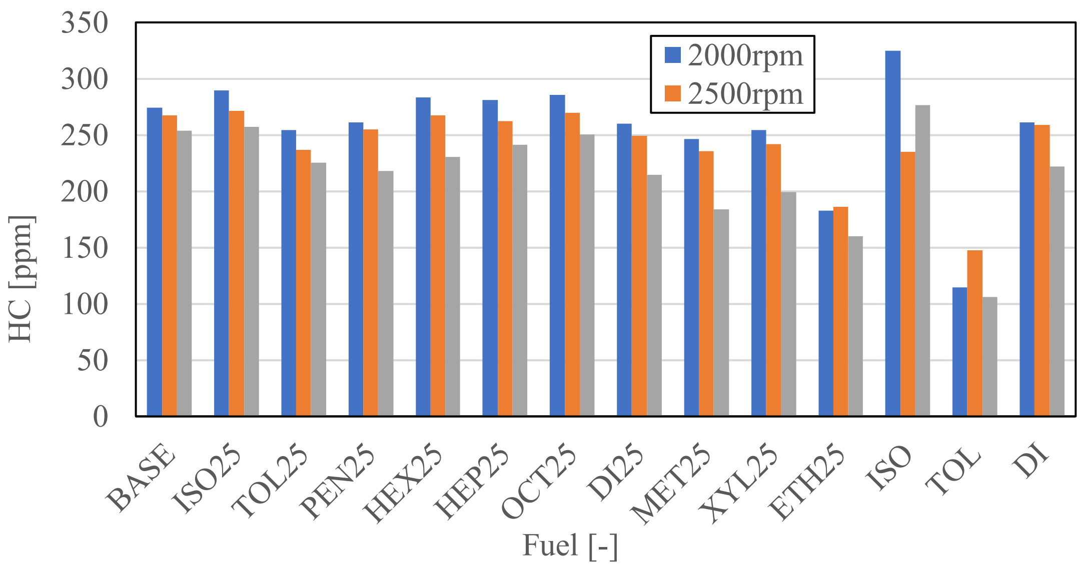

Fig. 6. HC emission (20%)

Figure 7 shows the CO emissions against fuel properties as a function of the engine revolution without engine load at constant throttle opening (20%). From this figure, it can be seen that the CO emissions of TOL addition fuels are bigger than that of other fuel additions. Furthermore, it is interesting fact that the CO emissions of ethanol are smaller than that of the other fuel additions. This fact indicated that the ratios of oxygen and hydrocarbon in the fuel are very important role for simultaneous reduction of HC and CO emissions for small gasoline engine.

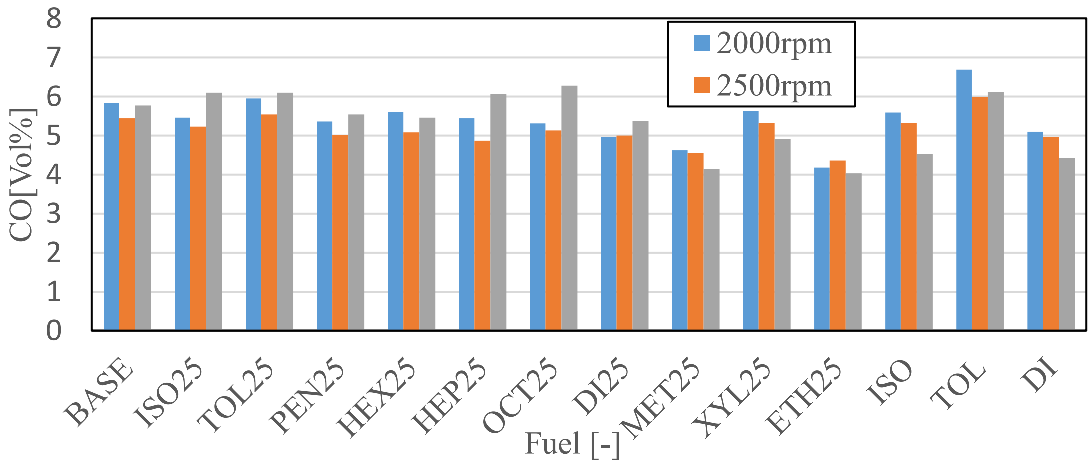

Fig. 7. CO Emission (20%)

Figure 8 shows the NOx emissions against the additional fuel properties as a function of engine revolution without engine load at constant throttle opening (20%). From this figure, it can be seen that NOx emission of TOL is bigger than that of other additional fuel at any engine revolutions. It is caused by increasing the flame temperature by the addition of TOL.

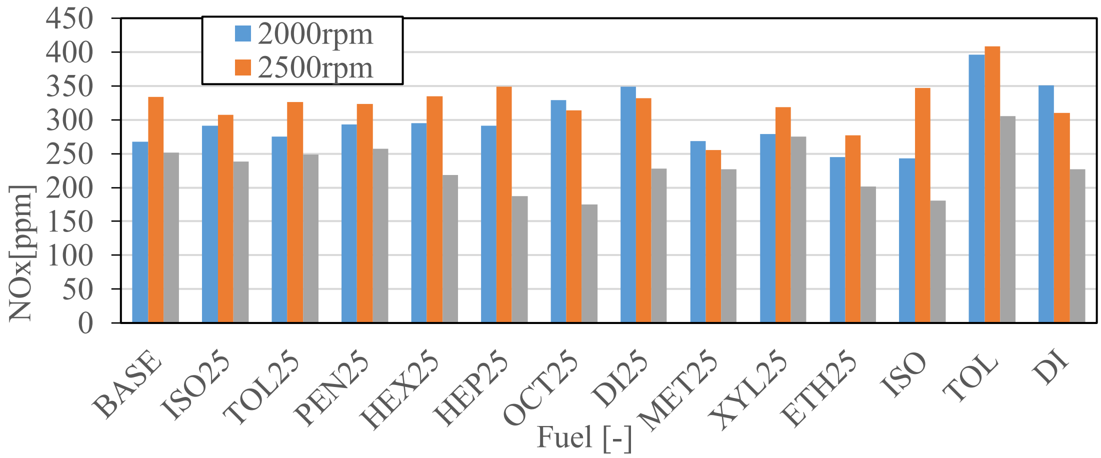

Fig. 8. NO_X Emission (20%)

4. Conclusions

Experiments have been carried out to examine the effects of fuel composition on the fuel properties and emission characteristics (HC, CO, NOx) by using multi component fuels in a small gasoline engine. The main conclusions are as follows:

1) The HC emissions decrease with increasing the evaporation rate of addition fuels for normal chain paraffin.
2) The CO emissions monotonically decrease with increasing excess air ratio by using multi component fuels.
3) It is possible to control the HC, CO and NOx emissions by using the fuel of 25-vol% ethanol addition for a small gasoline engine.

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