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EXPERIMENTAL STUDY OF EMISSION REDUCTION BY USING ALCOHOL BLENDED FUEL FOR SMALL GASOLINE ENGINE

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Abstract

In practical gasoline engines it is necessary to achieve low emissions and low fuel consumptions with high load operation. Several techniques were developed for reducing the emissions and the fuel consumptions from gasoline engines, such as EGR (exhaust gas recirculation) and Ultra lean combustion [1, 2]. Especially, in automotive gasoline engines, low-particulate and low-NO_x emissions are very much needed by using alcohol blend fuels and vegetable oil. Nevertheless, there are only few data available for reducing the emissions and fuel consumptions of small gasoline engines by using blended fuels.

As the first step in this study, experiments have been carried out to examine the influence of alcohol-blended fuels on combustion characteristics for small gasoline engines. The fuels used in this study are gasoline, methanol, ethanol, propanol and butanol. The addition of alcohol ratio are changed by mixing the volume of alcohol in gasoline and the addition ratios are from 0 to 30 vol% in the fuel. The main conclusions are as follows: 1) The NO_x emissions for all the alcohol blend fuels are smaller than that of gasoline. 2) The heat release rate increases with addition of alcohol fuel under higher load conditions for small gasoline engines.

Keywords: *low emission, small gasoline engine, alcohol-blended fuel*

1. Introduction

Nowadays, an approach to tighten an emission control for automobiles is advanced because of worsening environmental problems in the world and additional technology progress for combustion improvement is harder than expected. Actual engines are operated under high temperature and high pressure, so it is important to obtain the best combustion characteristics of gasoline-air mixture under such conditions from the viewpoint of automotive and combustion engineering.

A large number of studies for reduction of combustion emission from internal combustion engines have been conducted by using medium and large sized gasoline engines (200 cc to 3000 cc), but very few data for small sized gasoline engines because of the limitation of combustion chamber and measurement method.

As the first step in this study, experiments have been carried out to obtain the fundamental data for the influence of alcohol additions on combustion characteristics and emissions (NO_x, CO, HC, CO_2) in small sized gasoline engine. The combustion behaviour, such as maximum burning pressure and total burning time, is observed by measuring the pressure. The flame speed is measured by ionization probes at three different positions from the spark gap.

2. Experimental Apparatus and Procedure

Figure 1 shows the experimental set up employed in this study. It consists of a small sized gasoline engine (Honda motor Co. C50E: 50cc, 4-stroke), and an analyser of exhaust gas (AVL Di COM 4000: NOx: Chemiluminesence, CO and CO_2: NDIR, O_2: Zirconia), a dynamometer (Tokyo meter Co. EA-10-L), a dynamometer controller (Tokyo meter Co. BTE-5), an ignition system and an intake air equipment for small gasoline engine. Tab. 1 shows the specifications of the engine used in this study. The carburettor unit is interchangeable with an electric fuel injection system (EFI) 3). The EFI system specification is shown in Tab. 2.

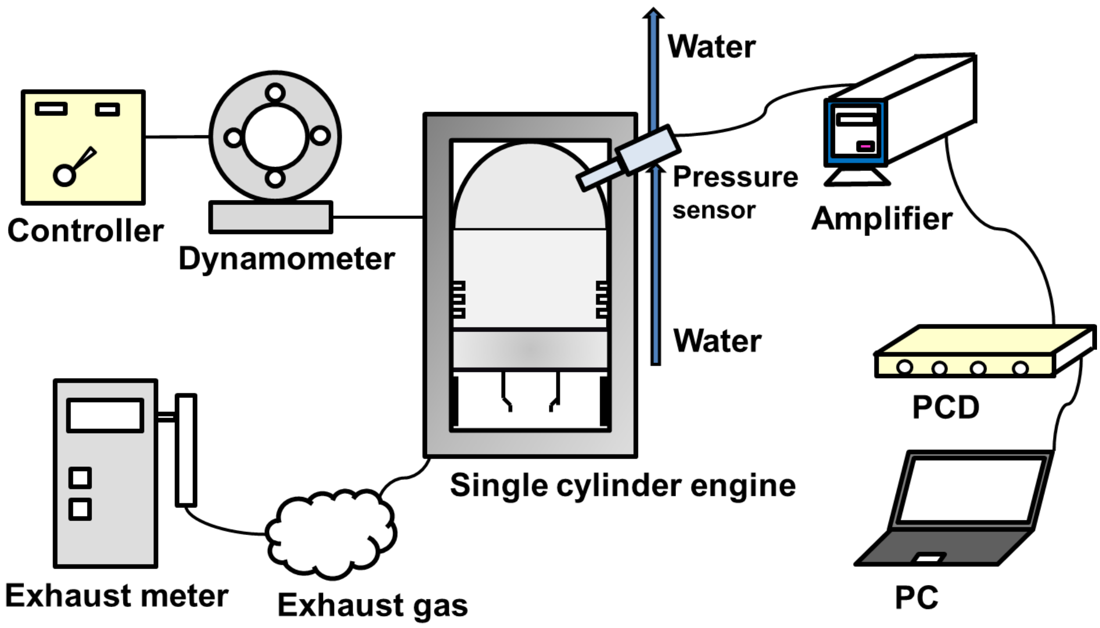

Fig. 1. Experimental device

Tab. 1. Engine specifications

Engine Type	C50E 4-stroke	Displacement [cc]	49
Number of Cylinders	Single Cylinder	Valve System	OHC
Ignition System	Spark Ignition	Compression Ratio [–]	11.0
Cooling System	Air-cooling	Maximum Output [kW/rpm]	2.94/7000
Bore × Stroke [mm]	39.0 × 41.4	Maximum Torque [Nm/rpm]	4.70/450

Tab. 2. EFI specifications

Type (throttle body)	FI-M-B	Type (controller)	FI-M-C
Material	Aluuminum alloy	Control circuit	Digital Logic Type
Weight	400 g	Weight	280 g
Power source	DC 12V	Size	25 × 95 × 125 mm

The travel time of flame front is measured by using ionization probes located at different positions from the ignition point of cylinder head (Probe 1: 6 mm length of flame propagation from ignition point, Probe 2: 10 mm and Probe 3: 12 mm). The flame speed was obtained from the electrical signal of ionization probes by using oscilloscope.

The maximum burning pressure and the total burning time are observed by measuring the pressure with a piezoelectric Kistler pressure transducer. Mean rate of pressure rise is calculated from the value which subtracted initial pressure of after compression stroke from the maximum burning pressure divided by total burning time.

3. Experimental results and decision

Figure 2 shows the maximum burning pressure against the throttle valve opening with engine load (average engine revolution: 3500 rpm) by using the alcohol blended fuels (addition rate of alcohol: 30 vol %):

- M30: Methanol 30 vol % and light oil 70 vol %,
- E30: Ethanol 30 vol % and light oil 70 vol %,
- P30: Propanol 30 vol % and light oil 70 vol %,
- B30: Butanol 30 vol % and light oil 70 vol %.

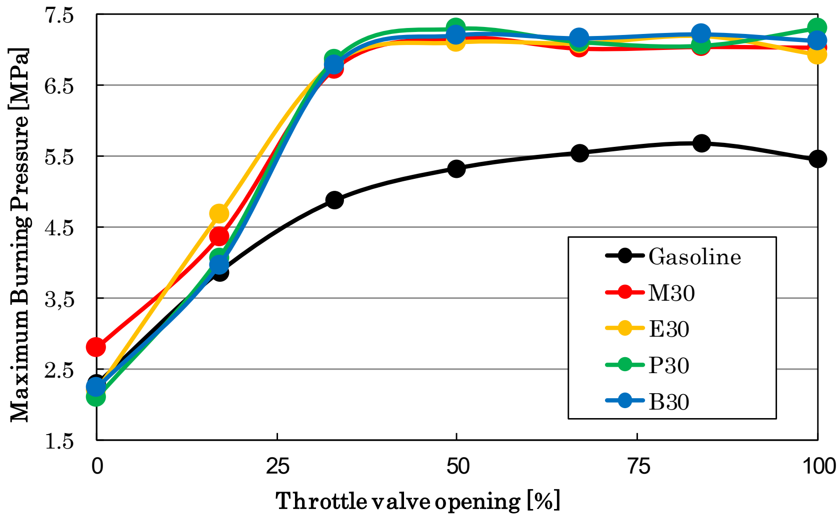

Fig. 2. Maximum burning pressure

From this figure, it can be seen that the maximum burning pressure for alcohol blended fuels are not so difference under 20% ratio of throttle valve opening. On the other hand, the maximum burning pressure over 30% ratio of throttle valve opening are bigger than that of light oil for any alcohol blended fuels. This fact indicated that alcohol blended fuels are effective of the combustion improvement of small sized gasoline engines.

Figure 3 shows the mean increasing rate of pressure against the throttle valve opening with engine load by using alcohol blended fuels (addition rate of alcohol: 30 vol%). From the figure it can be seen that the mean increasing rate of pressure of alcohol blended fuels are bigger than that of light oil at range from middle to high throttle valve opening (over 30%). Furthermore, it is interesting fact that under condition of over 30% throttle valve opening, the mean increasing rates of pressure are almost constant at any alcohol blend fuels. This fact indicated that it is possible to control the combustion behaviour in small gasoline engine by using the alcohol-blended fuels without the low throttle valve opening.

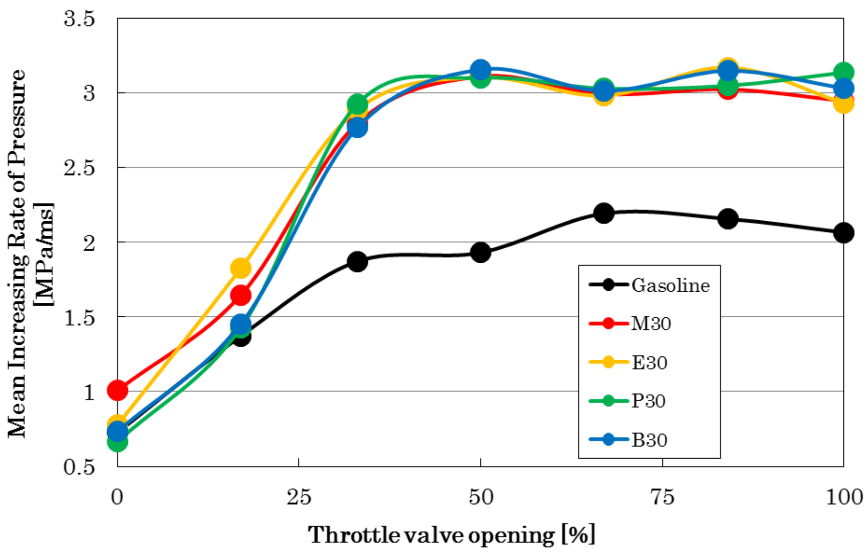

Fig. 3. Total burning time

Figure 4 shows the NO_x emissions against the throttle valve opening with engine road for alcohol blended fuels (addition rate of alcohol: 25 vol %):
– M25: Methanol 25 vol % and light oil 75 vol %,
– E25: Ethanol 25 vol % and light oil 75 vol %,
– P25: Propanol 25vol % and light oil 75 vol %,
– B25: Butanol 25 vol % and light oil 75 vol %.

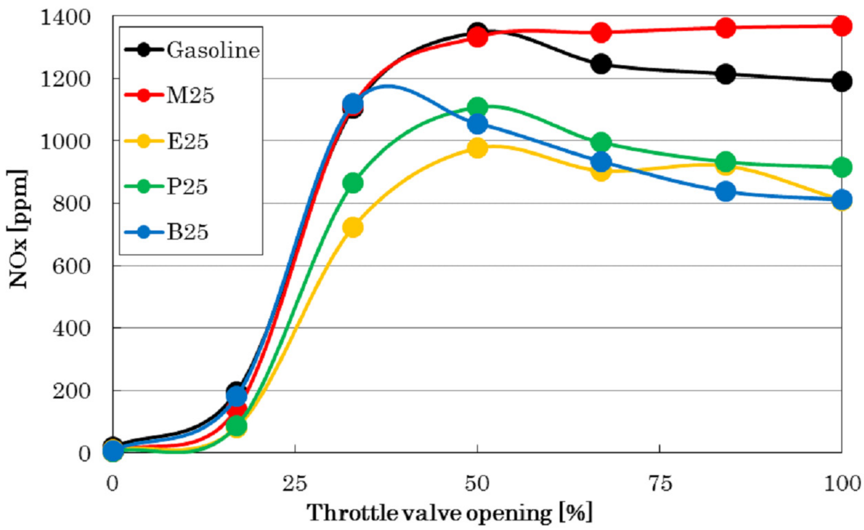

Fig. 4. NO_x emissions

As can be seen from this figure, NO_x emissions by using alcohol blended fuels are almost smaller that of light oil without the including methanol (M25) in the fuel. It is causes by the decreasing the flame temperature by the addition of alcohol [4, 5]. These results indicated that, the Alcohol blended fuels could possible to reduce the NO_x emissions for small sized gasoline engines.

Figure 5 shows the average reduction rate of NO_x as a function of blended fuel types (addition rate of alcohol: 10 vol %). The reduction rates of NO_x are calculated from the average NO_x concentration for alcohol-blended fuels divided by the average NO_x concentration of gasoline. From this figure it can be seen that, the all the alcohol blended fuels remarkably can possible to reduce the NO_x emission than that of gasoline.

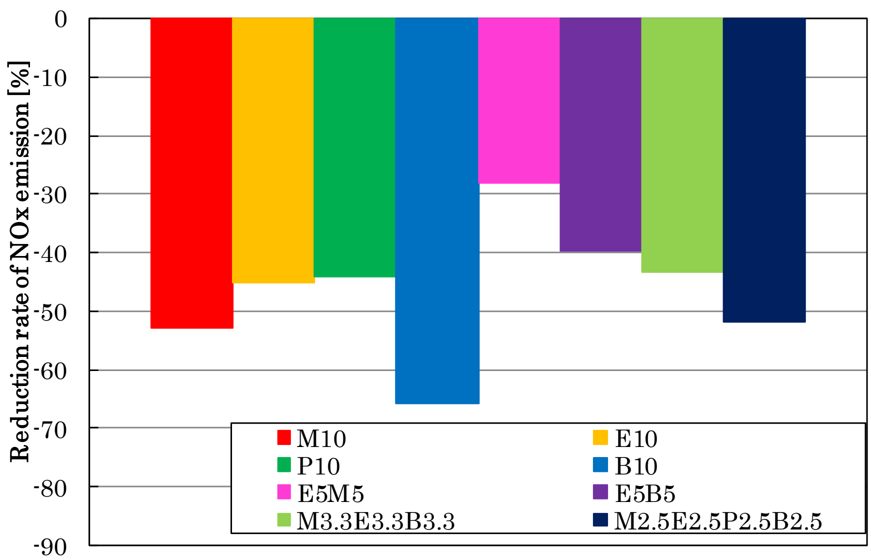

Fig. 5. Reduction rate of NO_x

Figure 6 shows the HC emissions against the throttle valve opening for alcohol blended fuels (addition rate of alcohol: 25 vol %). From this figure, the effects of alcohol blended properties on HC emissions are not much differences under higher throttle valve opening (50 ~ 100 %). On the other hands, under lower throttle opening regions (0 ~ 30 %) HC emissions for alcohol-blended fuels are bigger than that of the gasoline. From these results, it can be seen that, for reducing the HC emissions by using the alcohol-blended fuels, it is necessity to discuss the effects of the additional alcohol fuels and engine conditions.

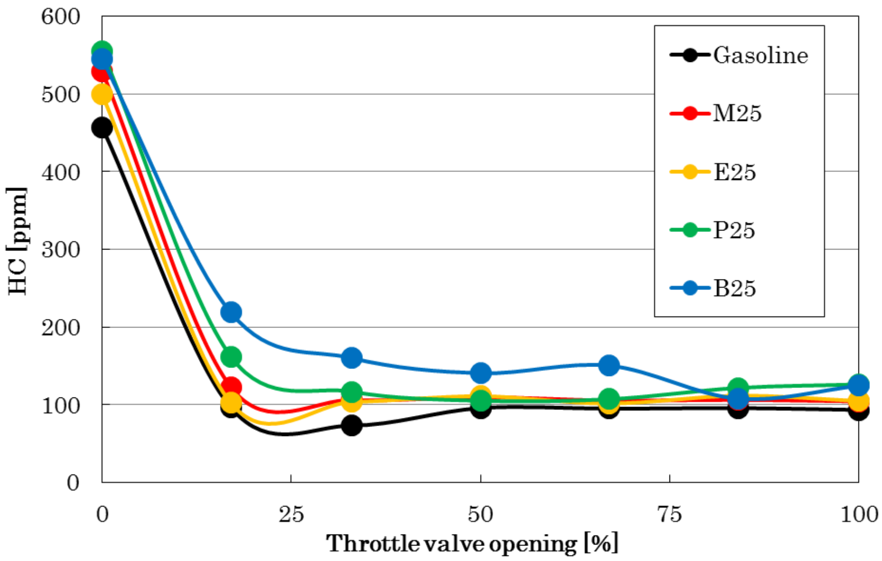

Fig. 6. HC emissions

Figure 7 shows the CO emissions against the throttle valve opening with engine road for alcohol-blended fuels (addition rate of alcohol: 25 vol %). As can be seen from this figure, for almost the alcohol-blended fuels, the CO emissions are higher than for gasoline at any throttle valve opening without fuel of the M25 and B25 at lower throttle valve opening (20 ~ 30 %). It is causes by the influence of decreasing carbon in the alcohol-blended fuels. Furthermore, the influence of fuel properties on CO emissions are bigger at Zero throttle valve opening than that of the higher throttle valve opening. This fact indicates that the amount of intake air is important role for CO reduction.

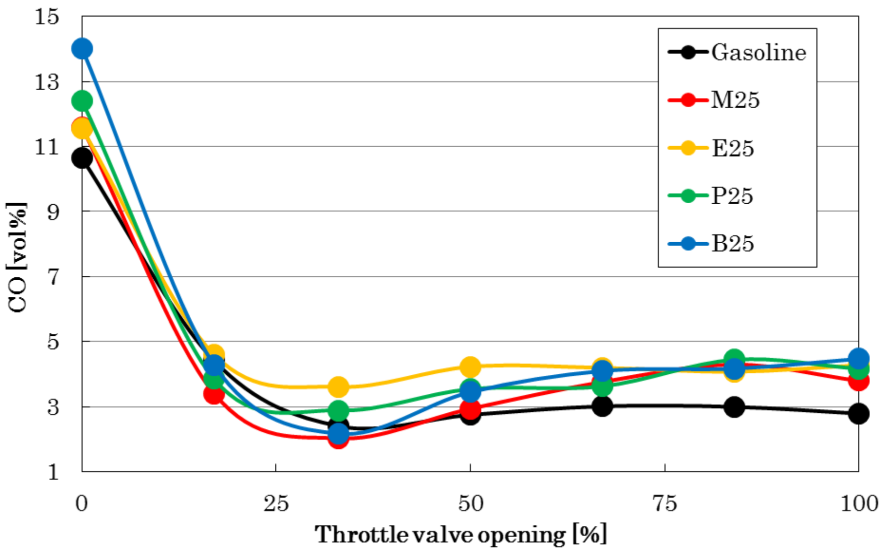

Fig. 7. CO emissions

Figure 8 shows the history of heat release rate against CA with engine road for alcohol blended fuels (addition rate of alcohol: 25 vol %). From this figure, the maximum heat release rates are bigger at any alcohol blend fuels than for the gasoline. Furthermore, the observation timing of highest value shifts to early CA than for gasoline fuel. It is explained that the effects of oxygen in alcohol blended fuels.

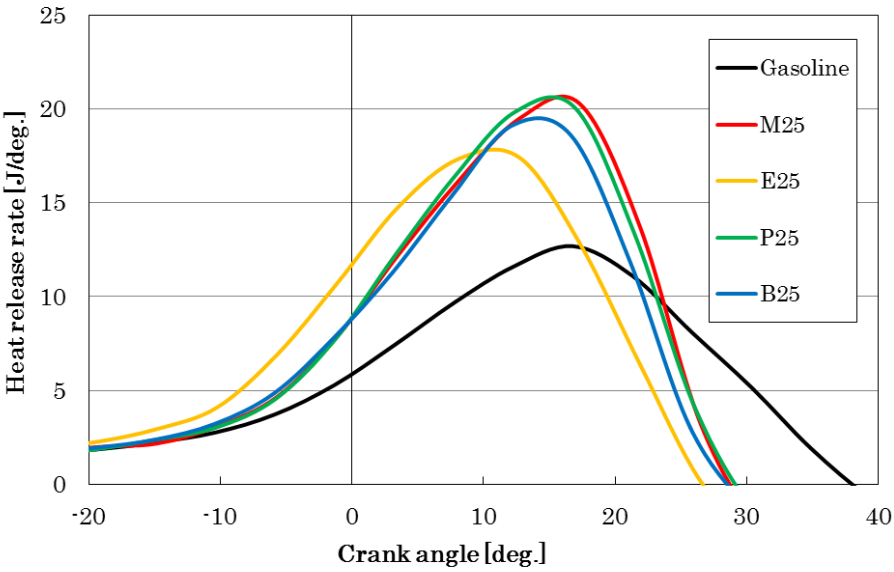

Fig. 8. Heat release rate

4. Conclusions

Experiments have been carried out to examine the influence of alcohol-blended fuels on combustion characteristics for small gasoline engine. The mail conclusions are as follows:

1) The NO_x emissions for all the alcohol-blended fuels are smaller than that of gasoline.
2) The heat release rate increases with addition of alcohol fuel under high load conditions for a small sized gasoline engine.

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