EXPERIMENTAL STUDY OF COMBUSTION IMPROVEMENT FOR SMALL GASOLINE ENGINE

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Abstract

In practical gasoline engines it is necessary to achieve a low emissions and low fuel consumption with high load operation. Several techniques were developed for reducing the emissions and fuel consumption from gasoline engines, such as EGR (exhaust gas recirculation) and Ultra lean combustion. Nevertheless, there are only very few data available for reducing the fuel consumption in small gasoline engines (50-125cc).

As the first step of this study, experiments have been carried out to examine the influence of oxygen concentration in intake air and fuel concentration on flame speed in small gasoline engine by using carburetor and EFI system. The flame front travel time was measured using ionization probes located at different point of cylinder head. The main conclusions are as follows: 1) the flame speed monotonically increases with increasing the engine rotation at any concentration in intake air; 2) Mean increasing rate of pressure is not affected by oxygen concentration in intake air and fuel concentration without load; 3) It is possible to improve the combustion behavior by using EFI system for small gasoline engine.

Keywords: *small gasoline engine, oxygen concentration, ionization probe, electronic fuel injection*

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 expected.

Actual engines are operated under high temperature and high pressure, so it is important to obtain 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 products from internal combustion engines have been conducted by using medium and large type gasoline engines (200cc to 3000cc), but very few data for small type 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 knowledge for the influence of oxygen concentration in intake air and fuel concentration on combustion behavior in small gasoline engine. The combustion behavior, such as maximum burning pressure and total burning time, is observed by measuring the pressure. The speed of flame front is measured by ionization probes [1)2)] at two 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 gasoline engine (Honda motor Co. C50E: 50cc, 4stroke), a dynamometer (Tokyo meter Co. EA-10-L), a dynamometer controller (Tokyo meter Co. BTE-5), an ignition system and intake air equipment for small gasoline engine. Table 1 shows the specifications of the engine used in this study. The oxygen concentration in intake air can be changed from 17 vol. % to 21 vol. % by connecting the portable air bag, and the fuel concentration is regulated by changing the needle jet in a carburetor (#42, #52, #65 and #72). The carburetor unit is interchangeable with an electric fuel injection system (EFI) [3)]. The EFI system specification is shown in Table 2.

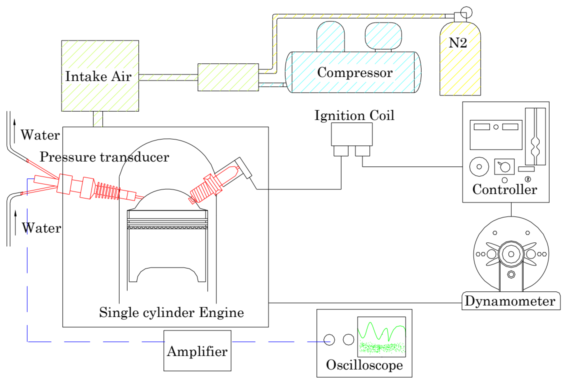

Fig.1. Control System

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: 6mm length of flame propagation from ignition point, Probe 2: 10 mm and Probe 3: 12mm). The flame speed was obtained from the electrical signal of ionization probes by using oscilloscope.

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

3. Experimental Results and Decision

Figure 2 shows the maximum burning pressure against engine revolutions without engine load. From this figure it can be seen that the maximum burning pressure increases with the increasing oxygen concentration at any engine revolutions. Furthermore, the maximum burning pressure increases with the elevating engine revolution. These results are quiet similar to the middle displacement gasoline engines.

Table 1 Engine Specifications

Engine Type	C50E 4stroke Cycle Single Cylinder
Ignition System	Spark Ignition
Cooling System	Air-cooling
Bore*Stroke	39.0mm*41.4mm
Displacement	49cc
Valve System	OHC
Compression Ratio	10
Normal Jet Number	#72
Maximum Output	3.3kW/7000rpm
Maximum Torque	5.1Nm/4500rpm

Table 2 EFI Specifications

Type (Throttle body)	FI-M-B
Material	Aluminum Alloy
Weight	400g
Type (Controller)	FI-M-C
Control circuit	Digital Logic Type
Size	25mm*95mm*125mm
Weight	280g
Power Source	DC12V

Figure 3 shows the total burning time against engine revolutions without engine load. From this figure it can be seen that the total burning time monotonically decreases with the increasing engine revolution, but rate of decrease is relatively larger for low engine revolutions than for high engine revolution region.

In this study, as the engine could not operate stably at low engine revolution region (2000 to 3000 rpm), the experiments had been carried out at rage of 3000 rpm to 5000 rpm with part load. From this figure, it can be seen that the mean rate of pressure rise increases with the elevating engine revolutions at any oxygen concentration as same as without engine load and its rate of increase is larger than without engine load. From the view point of the effect of flame temperature, the mean rate of pressure rise increases with the oxygen concentration. The effect of oxygen concentration in intake air on mean rate of pressure rise is getting smaller at range of high engine revolution region. These results indicated that, it is possible to control the combustion behavior by oxygen concentration in intake air for small gasoline engine with part load in operational condition (3000 to 5000rpm).

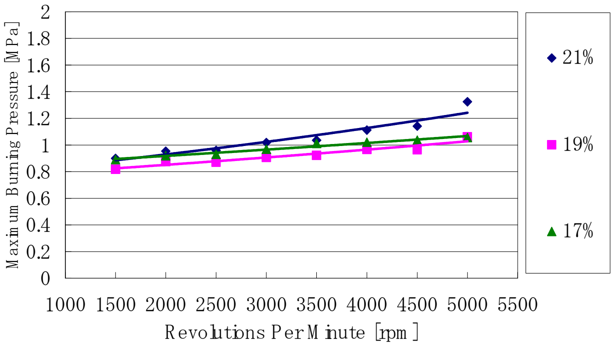

Fig.2 Maximum Burning Pressure (0Nm)

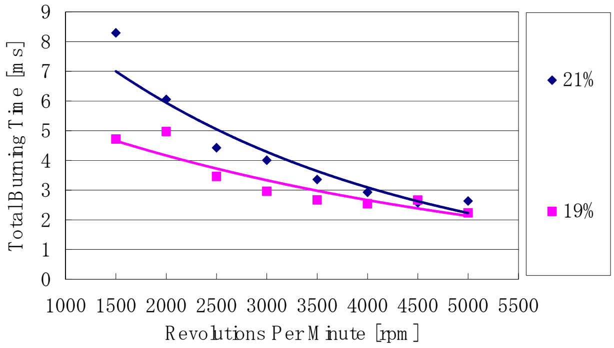

Fig.3 Total Burning Time (0Nm)

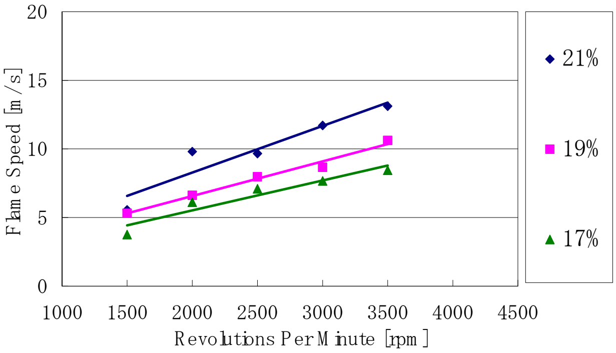

Fig.4 Flame Speed (0Nm)

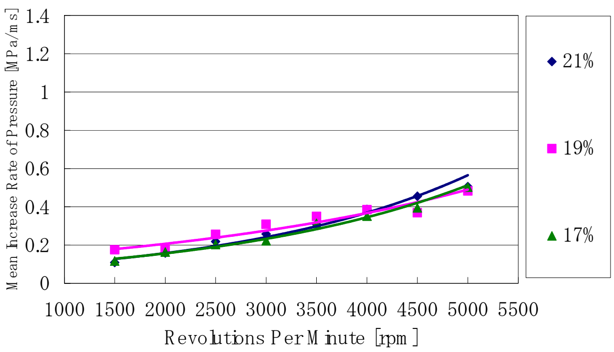

Fig.5 Mean Increasing Rate of Pressure (0Nm)

Figure 4 shows the flame speed against engine revolutions without engine load. From this figure, it can be seen that the flame speed increases with the increasing oxygen concentration at any engine revolutions. The rate of increase for flame speed is considerably large on the high revolution region (3000 to 3500 rpm) rather than on the low revolution region (1500 rpm). This fact can be readily explained by considering the effect of flame temperature. Furthermore, flame speed increases with the elevating engine revolution at any oxygen concentration. This result indicated that it is possible to control the combustion behavior by oxygen concentration in intake air for small gasoline engine.

Figure 5 shows the mean rate of pressure rise against engine revolutions without engine load. As can be seen from this figure, the mean rate of pressure rise increases with the increasing engine revolutions at any oxygen concentration. Furthermore, the effects of oxygen concentration on the mean rate seem to get nullified without engine load. The mean rate of pressure rise against engine revolutions with part load (0.78Nm) is shown in Figure 6.

Figure 7 shows the mean increasing rate of pressure against torque without engine load in case of using EFI system at three injection timings; intake stroke: BTDC 135 degree, expansion stroke: ATDC 45 degree, exhaust stroke: ATDC 142 degree. And the result used carburetor obtained from this study is also shown in it. Mean increasing rate of pressure increases with increasing the engine load at any injection timings. To focus attention to fuel supply system, mean increasing rate of pressure with using EFI system shows significantly higher level than results using carburetor. It indicates that it is possible to improve the combustion behavior with using EFI system for small gasoline engine.

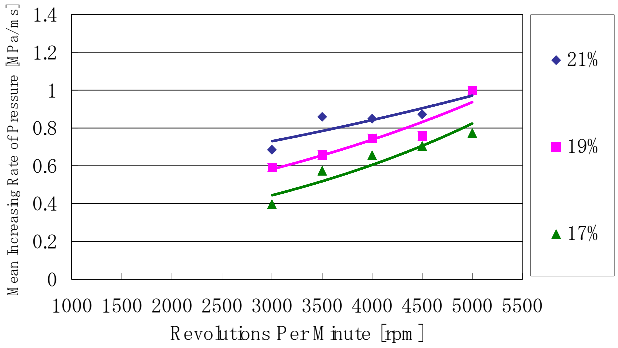

Fig.6 Mean Increasing Rate of Pressure (0.78Nm)

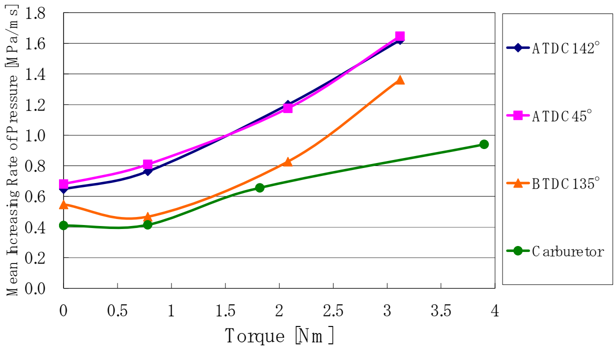

Fig.7 Mean Increasing Rate of Pressure (EFI)

4. Conclusions

In this study, we carried out the experiments on the combustion improvement for small gasoline engine. The results can be summarized as follows;

1) The flame speed monotonically increases with increasing the engine revolution at any oxygen concentration in intake air;
2) Mean rate of pressure rise is not affected by oxygen concentration in intake air and without load;
3) It is possible to improve the combustion behavior with using EFI system for small gasoline engine.

References

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