EXPERIMENTAL INVESTIGATION OF COMBUSTION CHARACTERISTICS FOR SPRAY COMBUSTION BY IMPINGING INJECTION IN A CLOSED VESSEL

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Abstract

Internal combustion engines are the major source of air pollution. Especially, compression ignition engines in today's automobiles contribute the most to particulate emission and soot, and it is recognized that these emissions have a detrimental effect on human and earth environment. So, an improvement of spray combustion for diesel engines is of urgent necessity.

Experiments have been conducted to obtain essential data on spray combustion influenced by impinging injection in a closed vessel. The effect of the impinging injection on maximum burning pressure, total burning time and flame speed is investigated at the condition of 300 K of initial temperature and 0.1 MPa of initial pressure. The travel time of flame front is measured by ionization probes located at two different positions from the center of combustion chamber.

The experimental investigations pointed out that the maximum burning pressure for impinging injection is larger than that of the single injection at the same overall equivalence ratio, the total burning time increases with increasing the overall equivalence ratio (after injection) at same equivalence ratio (before injection), the combustion of impinging injection is very effective for increasing the flame speed.

Keywords: *impinging injection, spray combustion, combustion characteristics*

1. Introduction

It is very important to achieve the low-particulate and low-NO_x emissions under high-load operation conditions in practical diesel engines. Several techniques for reducing the particulate and NO_x have been proposed and a large amount of experimental data has been published [1-3]. However, accurate data on combustion of practical diesel engines for reducing the particulate and NO_x are scarce to difficulties inherent in the conventional measuring techniques. It is well known that the flame behavior in practical diesel engines is strongly influenced by the behavior of injected droplets. Furthermore, the direct injection system has a problem of fuel deposition on the wall of the combustion chamber.

As the first step of the study, experiments were performed to provide basic data on maximum burning pressure, total burning time and flame speed under the influence of the impinging injection method in a closed vessel [4].

2. Experimental apparatus and procedure

Experimental setup is depicted in a schematic diagram shown in Fig.1. It consists of a cylindrical combustion chamber which is equipped with pintle type injection nozzles on each of the opposite walls along the length of the bomb. The size of combustion chamber, machined from a solid block of S45C, is 80 mm in diameter by 100 mm in length and its volume is approximately 500 cc. The diameter, pressure and angle of injection nozzle are 0.8 mm, 15.7 MPa and 15°, respectively. The Bosch type fuel pomp is provided to each injection nozzle. The combustion chamber is fitted with a piezo-electric pressure transducer for measuring the pressure during combustion process. The experiments were carried out at condition of 0.1-0.2 MPa in initial pressure and 293 K in initial temperature, and fuel is used hexadecane ($C_{16}H_{32}$). In this study, we call it "single spray" when the injection is performed by one nozzle and we call it "impinging spray" when the injection is performed at the same time by two nozzles facing each other. The nozzle distance for impinging spray is defined the distance between the nozzle and the opposite nozzle and the distance employed are 70 mm. The combustion behavior of impinging and single fuel spray, which are ignited by a spark ignition. The travel time of flame front is measure by ionization probes located at two different positions from the center of combustion chamber.

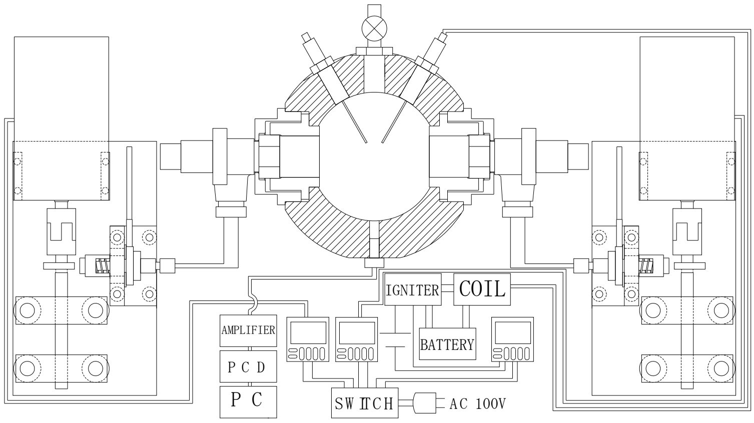

Fig.1 Schematic diagram of experimental apparatus

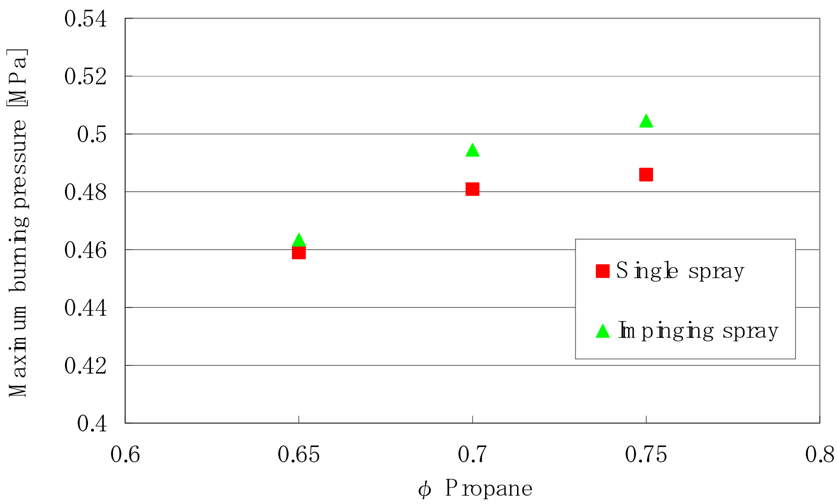

Fig.2 Maximum burning pressure vs. equivalence ratio

3. Results and discussion

Figure 2 shows the maximum burning pressure versus equivalence ratio (the equivalence ratio of propane-air mixtures before the injection) as a function of injection type, where the overall equivalence ratio after injection is about 1.08. From this result it can be seen that the maximum burning pressure decreases with decreasing equivalence ratio (before the injection) for both single and impinging spray. Furthermore, for the impinging spray, maximum burning pressure is larger than that of the single spray at the same equivalence ratio.

Figure 3 shows the maximum burning pressure versus equivalence ratio (before the injection) as a function of the overall equivalence ratio (after the injection) by using impinging injection. From this figure it can be seen that for at overall equivalence ratio Φ = 1.5, the maximum value of the maximum burning pressure can be observed at equivalence ratio (before the injection) Φ = 0.8. This tendency is observed at overall equivalence ratio Φ = 1.4. On the other hand, at overall equivalence ratio Φ = 1.3, the maximum value can be observed at equivalence ratio Φ = 0.75. This results suggest that the equivalence ratio (before the injection) of propane-air mixtures is a very important factor to achieve the improvement of spray combustion by impinging spray.

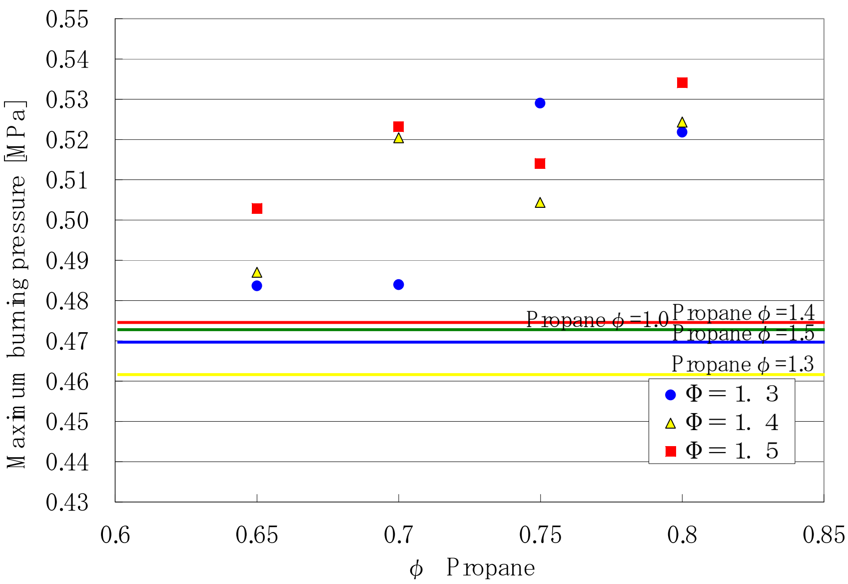

Fig.3 Maximum burning pressure vs. equivalence ratio

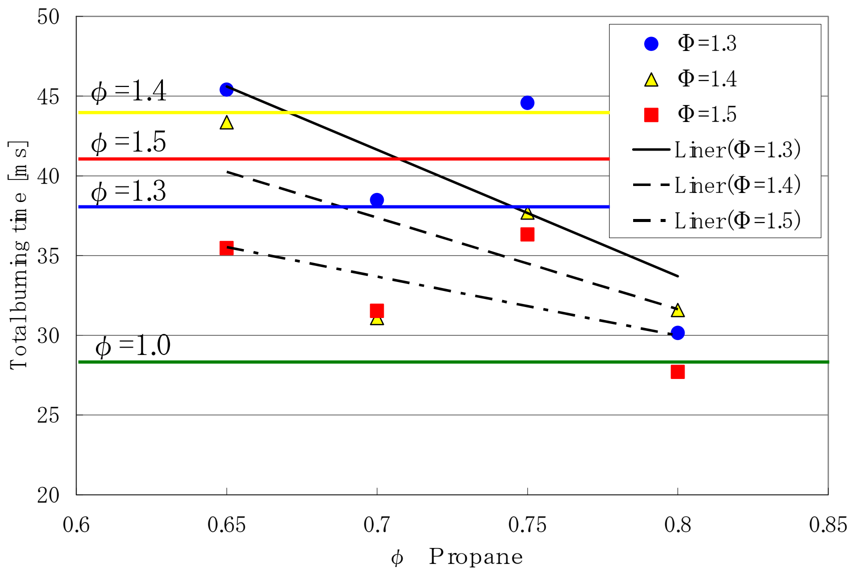

Fig.4 Total burning time vs. equivalence ratio

Figure 4 shows the total burning time versus equivalence ratio (before the injection) as a function of overall equivalence ratio (after the injection) by using impinging injection. As seen from this figure the total burning time decreases with decreasing the equivalence ratio (before the injection). The total burning time increases with increasing the overall equivalence ratio (after injection) at the same equivalence ratio (before injection). This phenomenon probably means that the fuel distribution near the stoichiometric conditions depends on the amount of fuel injected during impinging injection.

Figure 5 shows the mean flame speed versus equivalence ratio (before injection) for impinging injection. From this figure it can be seen that the mean flame speed monotonically increases with increasing the equivalence ratio at any overall equivalence ratio.

Figure 6 shows the flame speed versus equivalence ratio (before injection) for impinging injection. The flame speed is measured here by ionization probes located at two different positions from the center of combustion chamber. It can be seen that the flame speed increases with increasing the equivalence ratio at any overall equivalence ratio. Furthermore, this tendency is relatively larger for equivalence ratio of Φ = 1.5 than that of Φ = 1.3 and 1.4. It is very interesting fact that the combustion of impinging injection is very effective for increasing the flame speed.

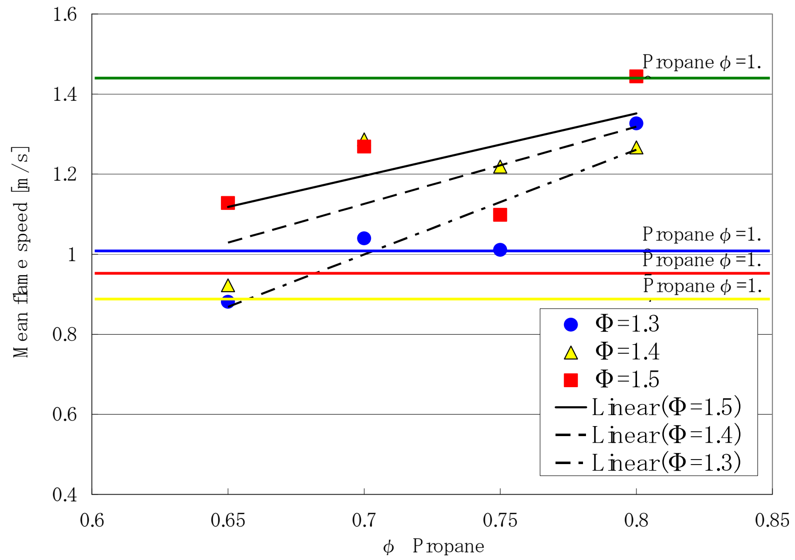

Fig.5 Mean flame speed

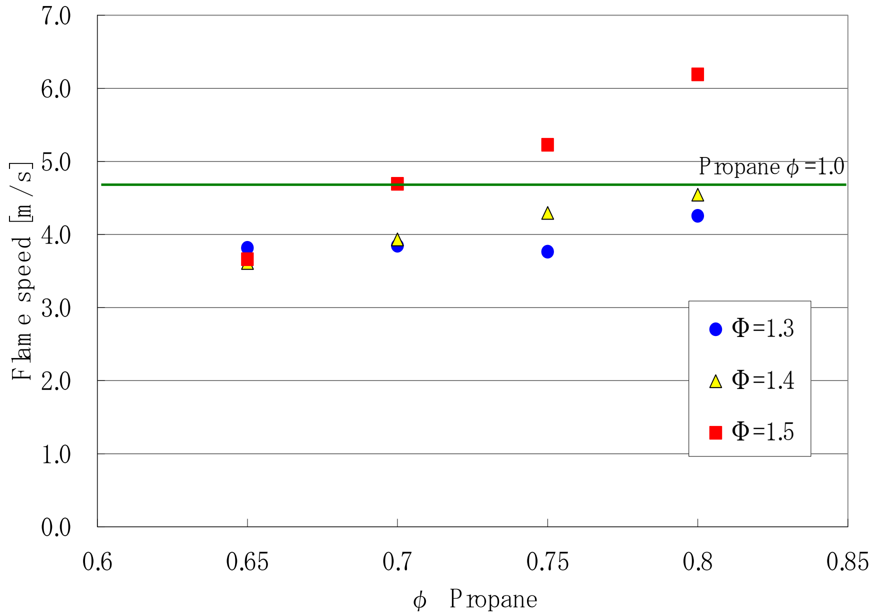

Fig.6 Flame speed

4. Conclusions

The experiments have been conducted in order to obtain the essential data on spray combustion by impinging injection in a closed vessel. The main conclusions are as follows:

1) The maximum burning pressure for impinging injection is larger than that of the single injection at the same overall equivalence ratio;
2) The total burning time increases with increasing the overall equivalence ratio (after injection) at same equivalence ratio (before injection);
3) The combustion of impinging injection is very effective for increasing the flame speed.

5. References

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