Study of Eucalyptus Oil and Its Application to Spark Ignition Engine (VI)

——Factors affecting flame propagation velocity——

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1. Introduction

There are several factors influencing the flame propagation velocity inside the cylinder of spark ignition engine. Some of the factors affecting the flame propagation velocity for the eucalyptus oil blend fuels were investigated previously by the authors[1]. They indicated that the flame propagation velocity for the eucalyptus oil blend fuels was increased with the engine speed and depended upon the blend ratio. The flame propagation velocity became large at the center of the cylinder and small near the cylinder wall. The ignition lag was slightly increased with the increase of the eucalyptus oil blended and decreased with the increase of the engine speed. The study on the flame propagation velocity as affected by air-fuel ratio of the eucalyptus oil blend fuels was not conducted and left for the future.

An experimental study was carried out to find the effects of air-fuel ratio upon the flame propagation velocity and ignition lag for the eucalyptus oil blend fuels. For varying the air-fuel ratio three types of carburetter main jet nozzles of different dimaeters were used in the experiment.

2. Experimental Equipment and Method

(1) Measurements of flame propagation

The flame propagation velocity was measured by using ion plugs (Fig. 1). Three ion plugs apart a particular distance from the spark plug were installed on the cylinder head of the engine as shown in Fig. 2. Three ion plugs were called No. 1 the nearest to the spark plug, No. 2 the middle and No. 3 the farthest. The electrical potential of 50 volts was applied between the insulated electrodes of the ion plug. When the flame front along which surface a high ionization was occurred reached an ion plug a current was caused between the insulated electrodes of the ion plug through the ionized flame front. The ion current resulted in the instantaneous drop of the voltage applied between the electrodes. Fig. 3 shows the

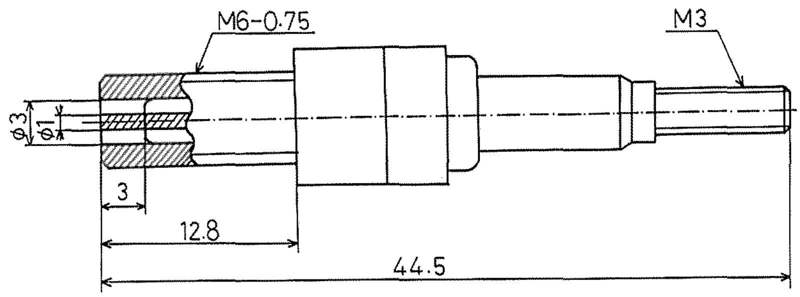

Fig. 1. Ion plug used.

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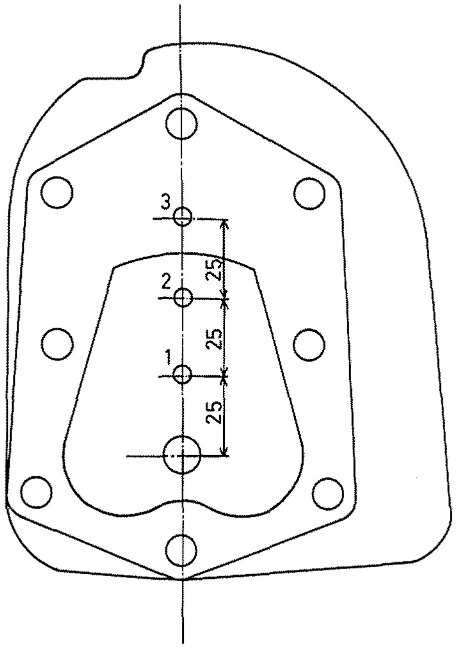

Fig. 2. The cylinder head used with the spark plug and three ion plugs installed in line and apart 25 mm each other.

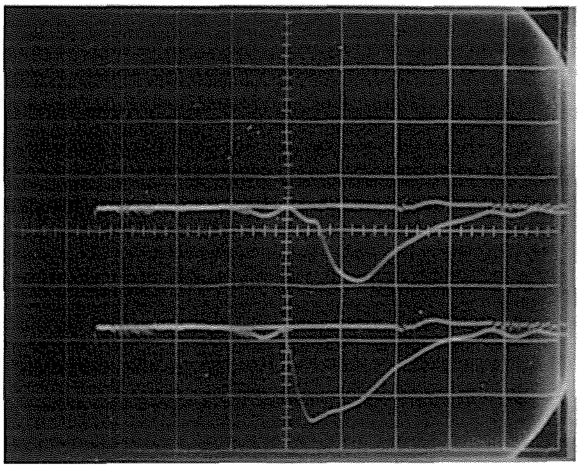

Fig. 3. The voltage drops taken by the polaroid camera.

picture of voltage drops taken by the polaroid camera on the oscilloscope. The time required for the flame to travel from the spark plug to an ion plug and also between the ion plugs was obtained by measuring the time between the two pulse waves with the counter. The flame poropagation velocity was calculated by dividing the distance between the spark plug and an ion plug by the time required for the flame to travel between the two plugs. The flame propagation velocity between the spark plug and the ion plug No. 1 (the nearest) was unable to be evaluated since the time required for the flame to travel this distance was considered to include a certain ignition lag. The ignition lag was estimated by an assumption that the propagation velocity from the spark plug to the ion plug No. 1 was same with the average velocity from the ion plug No. 1 to No. 3.

The specifications of the engine used are shown in Table 1.

Table 1. Specifications of the engine used.

Model	G700–P (Mitsubishi)
Kind of Fuel	Gasoline
Cooling System	Air Cooled
Cycle	4
Number of Cylinder	1
Bore × Stroke	72 × 63 (mm × mm)
Cylinder Displacement	256 (cc)
Compression Ratio	6.0
Rated Horse Power	5.0/3600 (ps/r.p.m.)
Max. Horse Power	7.0/4000 (ps/r.p.m.)

(2) Air flow measurement

In order to measure the amount of air lead to the carburetter a flow nozzle of which cross section had one quarter circle was used. This flow nozzle simple in structure provided an almost constant discharge coefficient even at the range of low Reynord's numbers[2]. The nozzle diameter was determined by considering the appropriate maximum pressure drop to be 100 mm head of water at the maximum engine revolution. Fig. 4 shows the dimensions of the flow nozzle used.

The measurement of air flow by use of flow nozzle is based upon the pressure difference before and after the nozzle. This is an application of Bernoulli's law which holds for constant and nonviscouse fluid. For the application to an internal combustion engine a surge tank must be used to eliminate the pulsation of air flow. Therefor the capacity of surge tank was decided to be 200 liters considering the types of engine used and assuming the minimum engine revolution to be around 1,800 r. p. m.

Fig. 5 shows a schematic of the calibration set-up for the air flow measurement. Water was filled in the standard tank up to a certain hight and then pumped out at a paticular rate of flow. The manometer

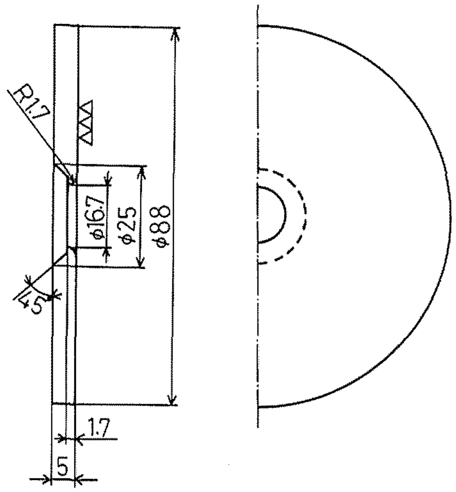

Fig. 4. Dimensions of the flow nozzle used.

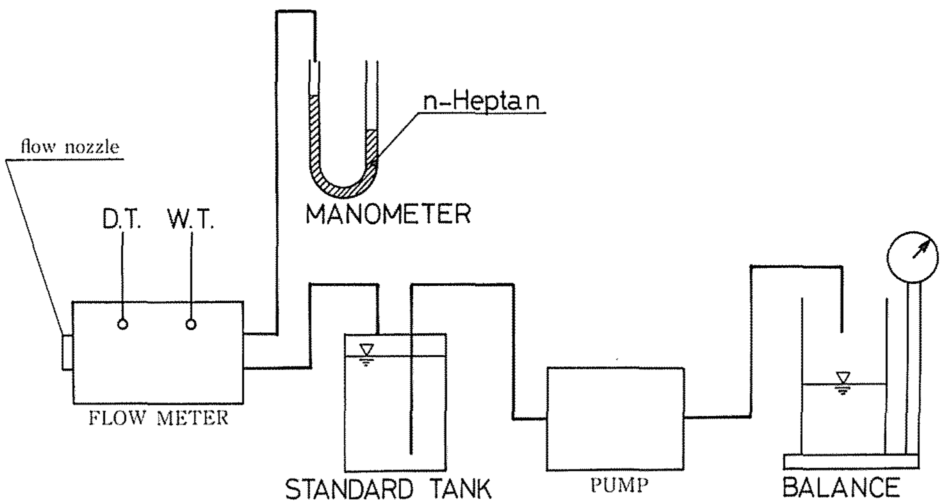

Fig. 5. Schematic of the calibration set-up for the air flow measurment.

readings, the weight of water discharged and the time required were measured for various flow rates. From the rate of air flow and manometer readings the coefficient of discharge was calculated to be 0.822[2]. Fig. 6 shows the relationship between the manometer reading and the rate of air flow.

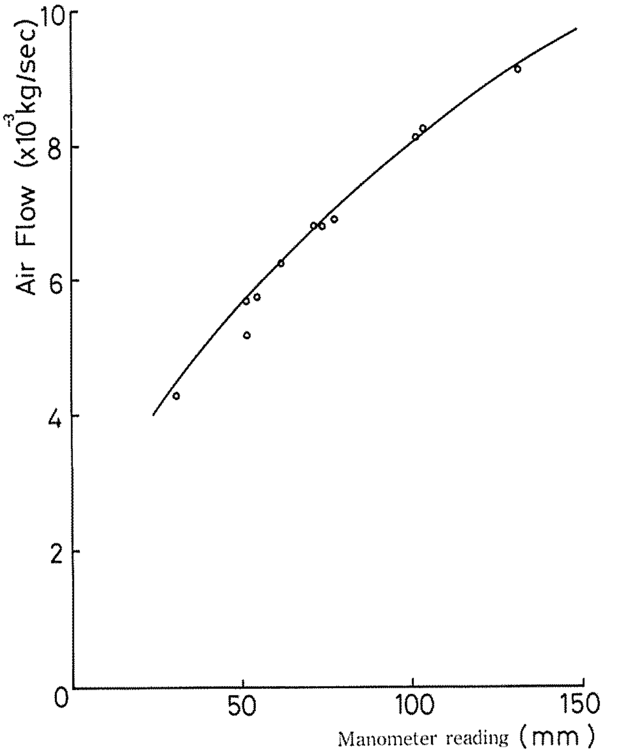

Fig. 6. Calibration curue for the flow measurement system.

3. Results and Discussion

The aim of the experiments was to investigate the effects of the eucalyptus oil blend fuels upon the flame propagation velocity and the other engine performance characteristics. The air-fuel ratio was varied by replacing the main jet nozzle of carburettor with different diameter nozzle. Fig. 7 shows the relationship between the blend ratio and engine performance characteristics including flame propagation velocity, ignition lag, excess-air factor and enzine output for the case of standard main jet nozzle of 0.82 mm diameter. The propagation velocity and the engine performance characteristics obtained for the larger main jet nozzles are shown in Figs. 8 and 9. The engine speed was fixed to be at 3050 rpm for each test.

For the case of the standard main jet nozzle of 0.82 mm diameter the propagation velocity increased with the increase of the eucalyptus oil up to 50 percent. Further increase of the eucalyptus oil decreased the propagation velocity. One of the reasons for the decreased propagation velocity in case of higher blend ratio of the eucalyptus oil was attributed to the increase of the excess-air factor which became more than 1. This meant that thinner mixtures was introduced to the cylinder preventing proper burning. The thinner mixture was apparently resulted from the higher viscosity of the eucalyptus oil which reduced the flow of blend fuel through the standard main jet nozzle for gasoline.

Figs. 8 and 9. shows the change of flame propagation velocity when the main jet nozzles of the carburettor were changed to a larger diameter of 0.92 mm and 1.00 mm respectively. The propagation

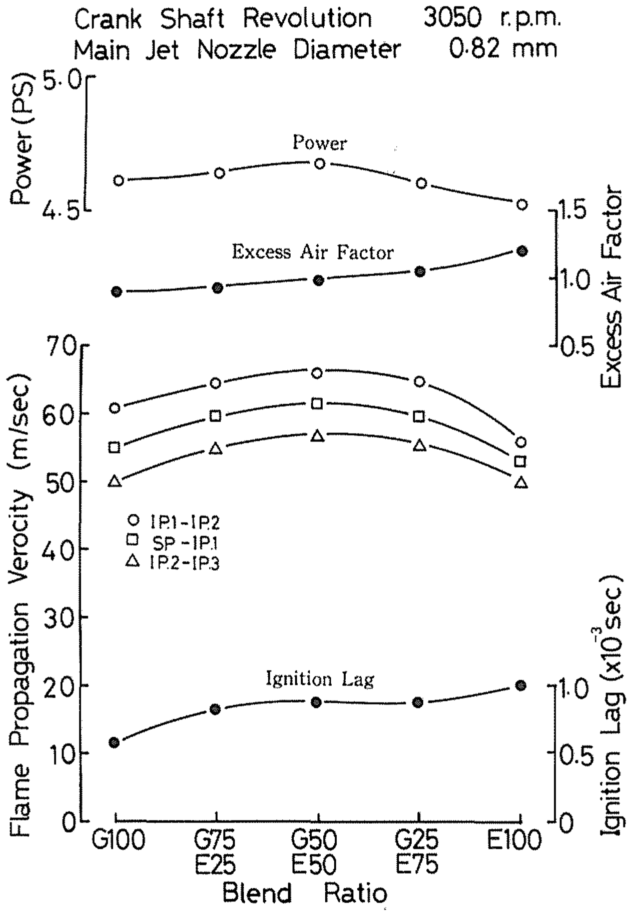

Fig. 7. Engine performance as affected by the bland ratio for the case of a standard nozzle.

velocities increased with the blend ratio of the eucalyptus oil when the excess-air factors did not exceed 1.0. For the case of using the larger diameter main jet nozzles the propagation velocities remained to be high even the blend ratio of the eucalyptus oil was increased considerably. As seen in Fig. 9 100 percent eucalyptus oil showed a large propagation velocity when the excess-air factor was close to 1. It seems apparent that whenever the excess-air factor came close to 1 better burning was attained and the increase in the velocity of flame propagation was resulted. For the excess-air factors either larger or smaller than 1 the propagation velocities were decreased since neither thin nor dense mixtures provided better burning.

In general the flame propagation velocity of eucalyptus oil blend fuel appeared to be somewhat higher that of gasoline. This results was also supported by the fact[4] that for the eucalyptus oil blend fuels better output was obtained by retarding the ignition time slightly.

The propagation velocity between the ion plugs No. 1 and No. 2, which was the velocity at the center of cylinder, was always greater than the velocities near the spark plug or near the cylinder wall. These results coincided with the results obtained in the previous research[1)3)] The engine output generally showed larger values when higher propagation velocities were attained.

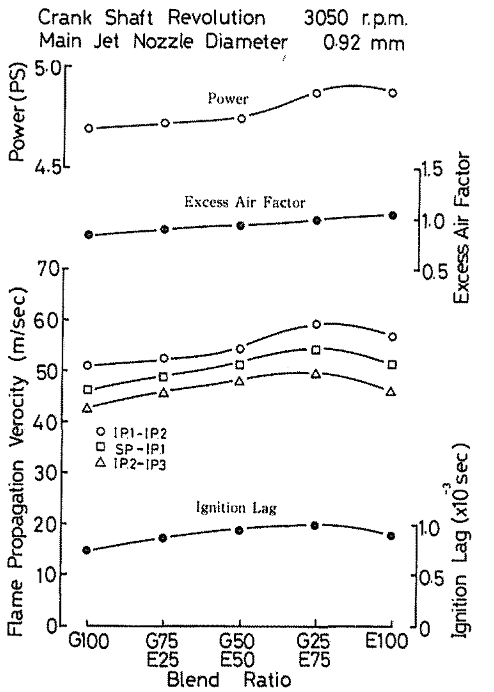

Fig. 8. Engine performance as affected by the blend ratio for the case of 0.9 mm diameter nozzle.

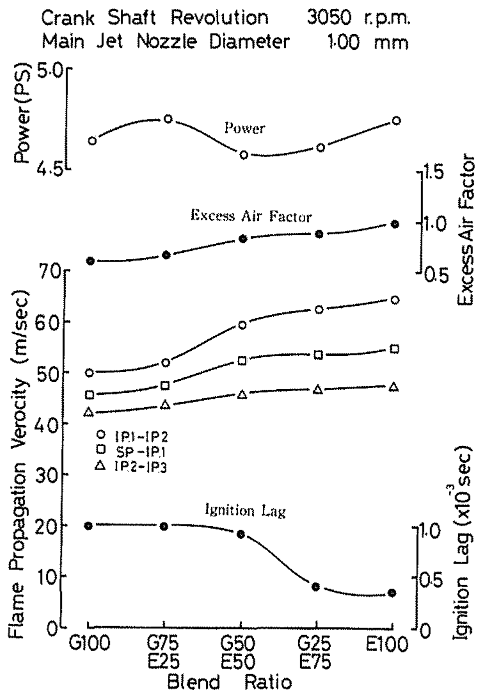

Fig. 9. Engine performance as affected by the blend ratio for the case of 1.00 mm diameter nozzle.

4. Summary and Conclusions

1. The effects of the eucalyptus oil blend fuels upon the flame propagation velocity and engine performance was investigated changing the air-fuel ratio as well as the blend ratio.
2. The flame propagation velocity of the eucalyptus oil appeared to be slightly higher than gasoline.
3. The propagation velocity was increased with the blend ratio of the eucalyptus oil so far as the excess-air factor was kept close to 1.0.
4. The propagation velocity was closely related to the excess-air factor and showed the largest values when it became close to 1.

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梗　　概

ユーカリ油の火花点火機関への応用（第6報）

法貴　誠・竹田策三

ユーカリ混合燃料を用い，空燃比を一定の範囲で変化させエンジン燃焼室内の火災伝播速度を調べた。エンジンに流入する空気流は脈動をともなうのでこれを除くためサージタンクを設けタンクには四分円ノズルを取付けマノメーターでタンク内外の圧力差を読むことにより流量を測定した。また空燃比を変えるためにはキャブレターのメインジェットノズルの内径の異なるものを用い燃料の流量を変えることにより空燃比を変化させた。実験の結果ユーカリ油の火災伝播速度はガソリンよよ少し速いことが判った。また空気過剰率が1に近い場合はユーカリ油の混合割合の増加ともに火災伝播速度が増加する傾向がみられた。火災伝播速度は空気過剰率に影響されその値が1に近づくとき最高の値となったが1以上または以下に大きく変化すると適正燃焼が行なわれず火災伝播速度は小さくなった。