Study of Eucalyptus Oil and its Application to Spark Ignition Englne* (IV)

Sakuzo TAKEDA** and Makoto HOKI**

Abstract

Experimental research was initiated to evaluate eucalyptus oil blend fuel as alternatives for spark ignition engine. The study consisted of the two parts.

Part I of the study dealt with the distillation curves of various blending ratio of eucalyptus oil, alcohol (ethanol) and gasoline. The study also included the water tolerance of the blended fuels. The 5% of water was added to the blended fuels to measure the engine performance including the output and fuel consumption.

Part II of the study dealt with the flame propagation velocity for various blend fuel. Measurements made by ion plug method revealed that the flame velocity for the fuel of a particular blend ratio was greater than that of pure gasoline.

Part I (a) Characteristics of the blend fuels

1. Introduction

Distillation curves is one of the important characteristics for evaluating suitability of the fuel for spark ignition engine. This research aimed to find the relationship between the distillation curves and engine performance using the eucalyptus oil, alcohol (ethanol) and gasoline blend fuels. The another purpose was to obtain the relationship between the water content and phase separation of the blend fuels.

2. Experimental Method

The distillation test (ASTM D86)[1] is an important test related to the operating characteristics of fuel.

A sample of 100 *ml* of the fuel to be tested was placed in a distilling flask (Fig. 1), and heat was applied at a specified uniform rate until the first drop fell from the condenser. The thermometer was read, and this reading was called the initial boiling point. Heating was continued, and the temperature was read as each one-tenth part of the sample was distilled over. Distillation curves were obtained for various types of the blend fuel.

In order to find the water tolerbility the blend fuel of 100 *ml* was put in a dry glass flask. The 0.1 volume percent water each of 1 *ml* metered by micro syringe were added until a haze situation indicating the saturation point was reached. The water content at this point was plotted as water tolerability in a triangular diagram.

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** Professor and Associate Professor respectively, Department of Agricultural Machinary, Mie University, Tsu 514, JAPAN.

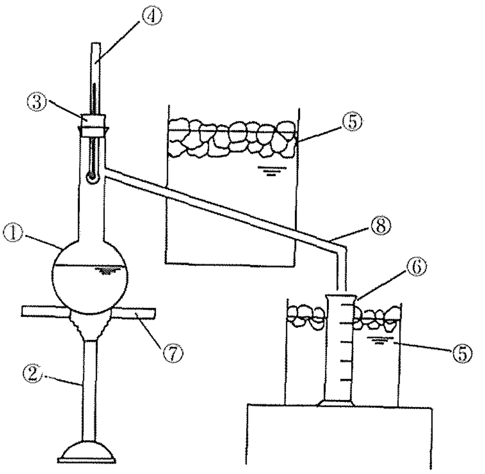

Fig. 1. Schematics of the apparatus for making distillation tests.

3. Results and Discussion

Fig. 2 shows the distillation curves of eucalyptus oil, alcohol and gasoline blend fuel. Regular gasoline for automobile was used in the tests.

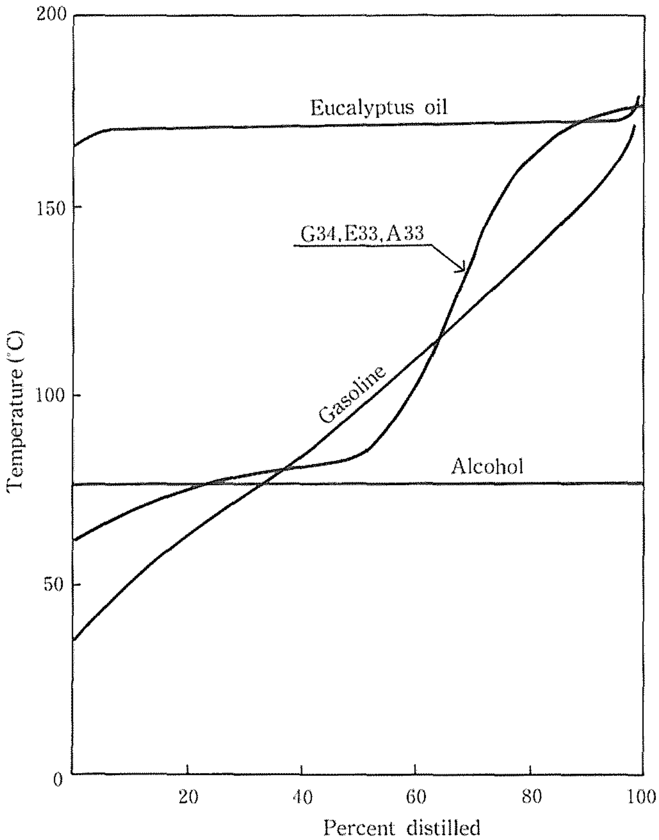

Fig. 2. Characteristic distillation curues of fuels tested.

Initial point was 172°C for eucalyptus oil, and 77°C for alcohol (ethanol), and 40°C for gasoline each. The distillation curve of this blend fuel showed similar characteristics to 100% gasoline.

Usually a small percent of water is contained in fuel because of the fuel tank respiration and temperature change. Water content in gasoline causes phase separation occasionally.

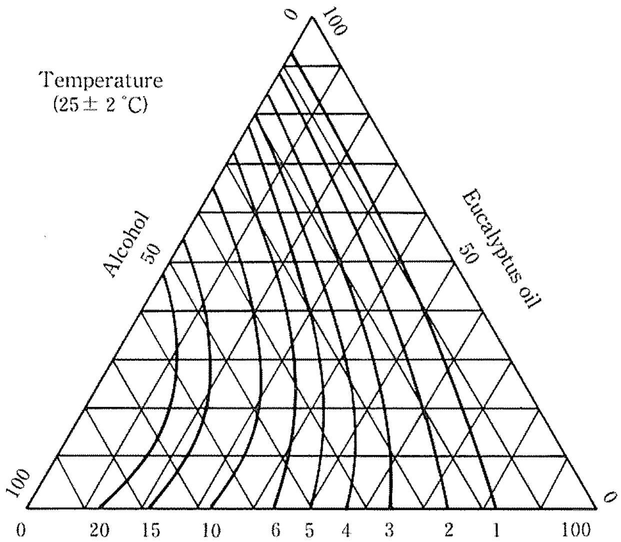

Fig. 3. Isowater tolerace lines.

Fig. 3 is Isowater tolerance line on ternary diagrams of eucalyptus oil-alcohol-gasoline obtained from the experiments[4].

This line has been drawn by joining all the points of equal water tolerability, defined as gram of water for 100 grams of gasoline/alcohol/eucalyptus oil blend (Fig. 3).

Part I (b) Engine performance by the blend fuels with 5% water

1. Introduction

As we have described a small percent of water is contained in fuel. The test was done to evaluate the engine performance, fuel consumption rate and emission characteristics for the blend fuels of 5% water content.

2. Experimental Method

Mitsubishi N25L-3, 4 cycle, single cylinder engine was used in the test. Table 1 shows the specification of the test engine. The engine was connected to the 3.7 KWH capacity of electric dynamometer.

The test was conducted on the engine performance, fuel consumption rate and the emission characteristics.

Table 1 Specifications of engine used for performance tests

Specification of Engine	
Model	N 25 L-3
Kind of Fuel	Gasoline
Cooling System	Air Cooled
Cycle	4
Number of Cylinder	1
Bore × Storoke	60×50 mm × mm
Capacity	141 cc
Compression Ratio	6.0
Rated Horse Power	2.5/3,600 ps/r.p.m.
Max. Horse Power	3.5/4,000 ps/r.p.m.

3. Results and Discussion

Fig. 4 shows the engine performance in case of using the fuels without water content and with 5% water respectively.

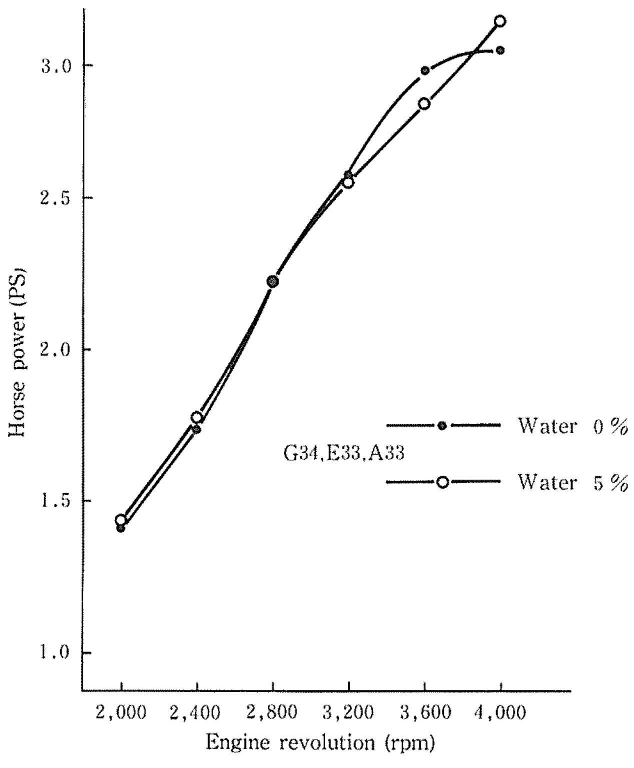

Fig. 4. Engine performamce test.

Within the limit of this experiment they showed about same performance at each revolutions. Fig. 5 shows the fuel consumption test.

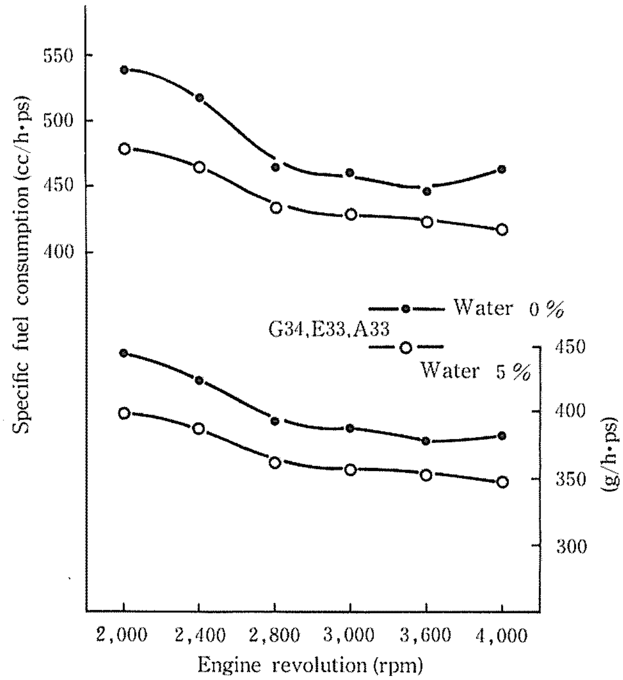

Fig. 5. Fuel consumption test.

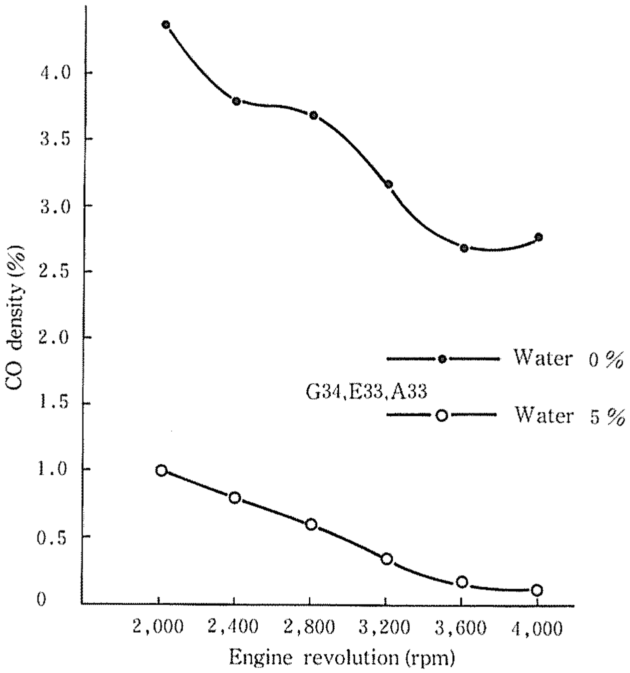

Fig. 6. CO density vs engine revolution.

About 9% reduced in case of 5% water content fuels.

It was probably due to the increase of charging efficiency by the heat of water resolution in explosing stroke.

Fig. 6 shows the carbon monoxide in emission.

It should be noted that the carbon monoxide in emission was reduced greatly for the blend fuel (E33/A33/G34) containing 5% of water.

Conclusion

The blend fuel of E33/A33/G34 is expected to have easy start, smooth acceleration and less vapourlock tendency. The distillation curve of this fuel shows similar characteristics to gasoline.

The blend fuel of E33/A33/G34 may be appropriate as alternative fuel for the spark ignition engine.

Eucalyptus oil increased the water tolerability of the blend fuels since the eucalyptus oil had the effect of preventing the phase separation of gasoline.

Part II Flame Propagation Velocity of Eucalyptus Oil Blend Fuel

1. Introduction

One of the important factors in the correct operation of any spark ignition engine is the time of occurrence of the ignition. Another important factor is the flame propagation velocity. That is, the conbustible mixture of fuel and air must be ignited so that the piston will receive the force of the explosion just as it reaches top dead center at the end of the compression stroke. Furthermore, it should be noted that the occurrence of the spark and the explosion of the mixture are two separate actions and are not simultaneous. Before an explosion can take place, the ignition must be spread throughout the entire mixture. A very short but certain period of time is required for the propagation of the flame through the mixture. The flame propagation velocity is depended upon several factors, such as the fuel used, the compression pressure, the load on the engine, the speed and the cylinder temperature.

An experimental study was conducted to investigate the flame propagation velocity and ignition lag when the eucalyptus oil blend fuels were used.

2. Experimental Method

The flame propagation velocity of the eucalyptus oil blend fuels were measured by·ion plug method (Fig. 7). Three ion plugs (Fig. 8) apart a particular distance from the spark plug were installed on the cylinder head of the engine used for the test. The method utilized the high ionization of the flame front of the mixture. The electric potential of about 100 volts was applied between the insulated electrodes of the ion plug. When the flame front reached an ion plug an ion current was caused between the electrodes. The time required for the flame to travel from the spark plug to an ion plug and also between the ion plugs was obtained on an oscilloscope (Fig. 9). The flame propagation 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 specifications of the engine used are shown in Table 2.

The flame propagation velocity between the spark plug and the ion plug No. 1 (the nearest one to the spark plug) was unable to be evaluated since the time required for the flame propagation of this distance included certain ignition lag. The ignition lag was estimated by assuming that the propagation velocity from the spark plug to the ion plug No. 1 was same with

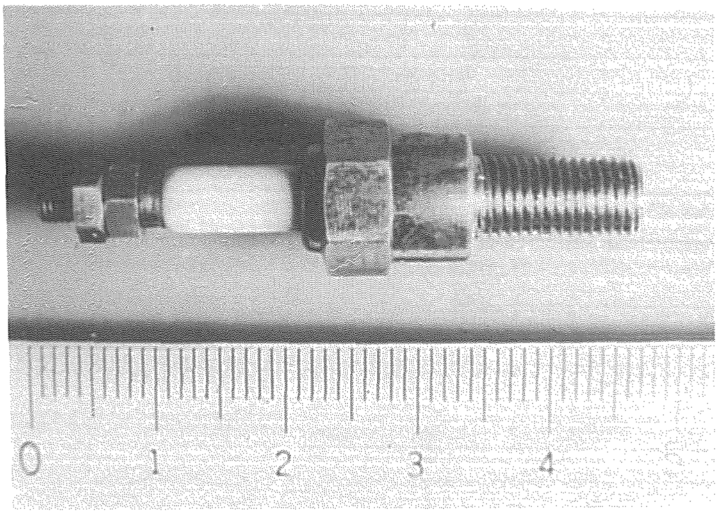

Fig. 7. Ion plug used for the tests. (scale in cm)。

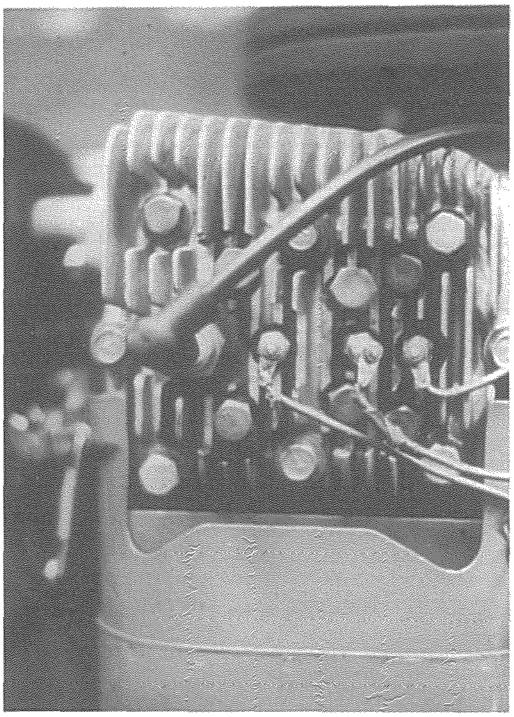

Fig. 8. Ion plugs installed on the cylinder head (From left to right, spark plug, ion plug No.1, ion plug No.2 and ion plug No.3).

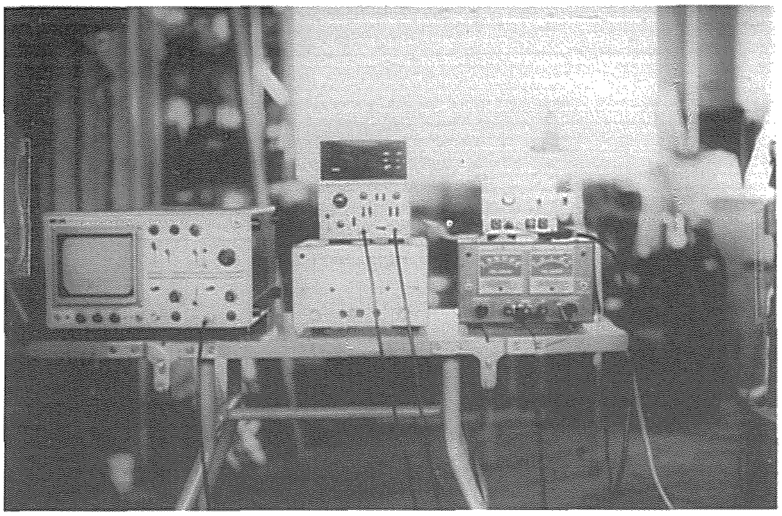

Fig. 9. Measuring and recording system of flame propagation velocity.

Table 2 Specifications of engine used for flame propagation velocity measurements

Specification of Engine	
Model	G 700 P(Mistubishi)
Kind of Fuel	Gasoline
Cooling System	Air Cooled
Cycle	4
Number of Cylinder	1
Bore × Storoke	72×63 mm × mm
Capacity	256cc
Compression Ratio	6.0
Rated Horse Power	5.0/3,600ps/r.p.m.
Max. Horse Power	7.0/4,000ps/r.p.m.

the average velocity between the ion plug No. 1 and No. 3.

3. Results and Discussion

The propagation velocity depended upon the type of the blend fuel, the operating condition and the location inside the cylinder. The upper three curves in Figs. 10, 11 and 12 shows the relationship between the blend ratio of the eucalyptus oil and the propagation velocity. The ignition lag is also shown as the bottom curve in each figure. The propagation velocity increased with the increase of the eucalyptus oil up to 50%. Further increase of the eucalyptus oil decreased the propagation velocity. This tendency was same for other operating condition with different engine speeds. The propagation velocity between the ion plugs No. 1 and No. 2 (at the center of cylinder) was always greater than velocities measured between the ion plug

No. 2 and No. 3. Naturally the velocity between the ion plugs 2 and 3 was small since the location was far from the spark plug and near the cylinder wall. This result coincided with

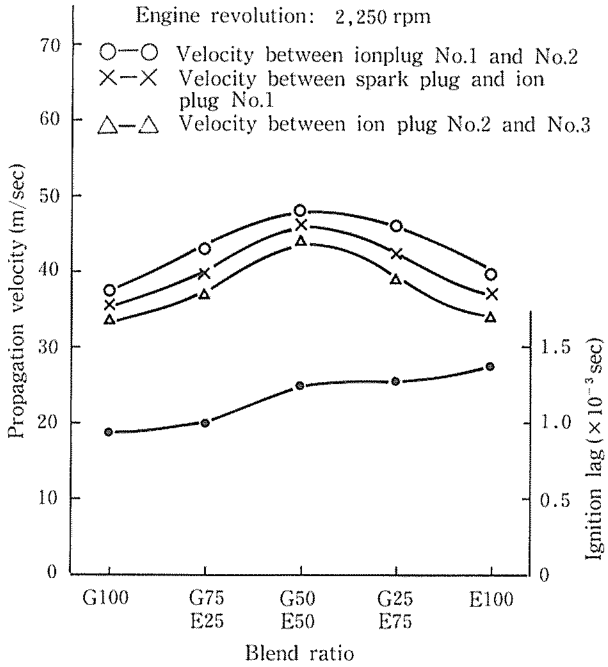

Fig. 10. Propagation velocity and ignition lag as affected by the blend ratio at 2,250 rpm.

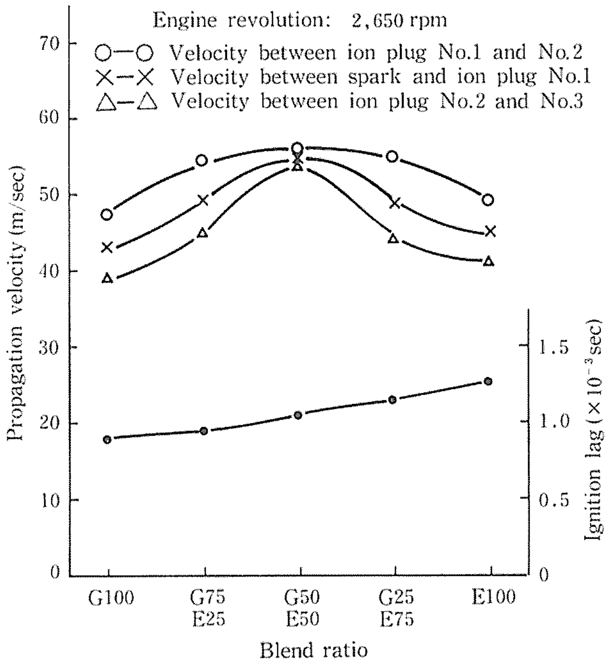

Fig. 11. Propagation velocity and ignition lag as affected by the blend ratio at 2,650 rpm.

the result obtained by other researchers (5). The ignition lag was the shortest for the 100% gasoline and increased with the increase of blend ratio of the eucalyptus oil.

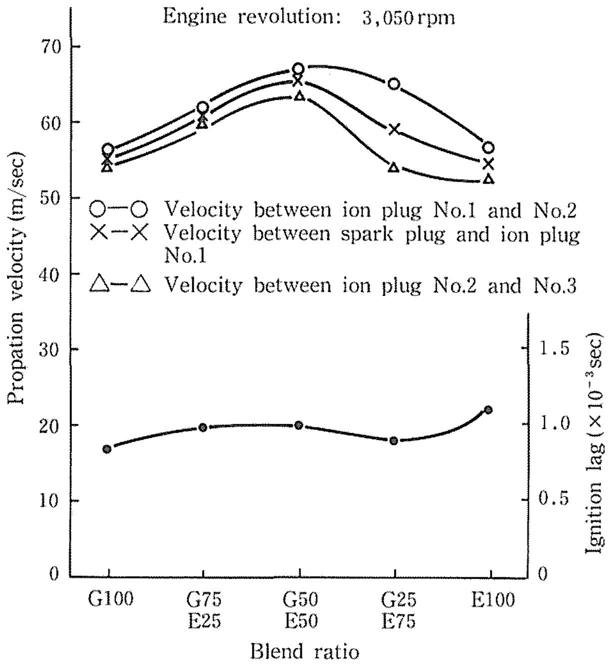

Fig. 12. Propagation velocity and ignition lag as affected by the blend ratio at 3,050 rpm.

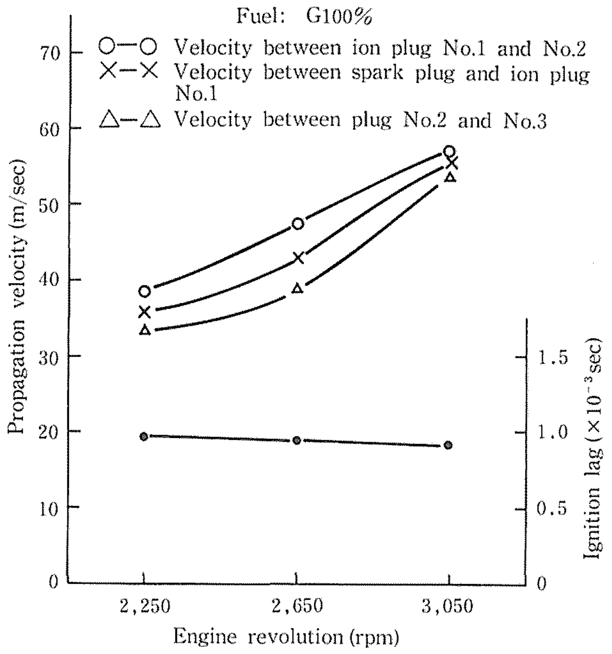

Fig. 13. Propagation velocity and ignition lag for the 100 % gasoline.

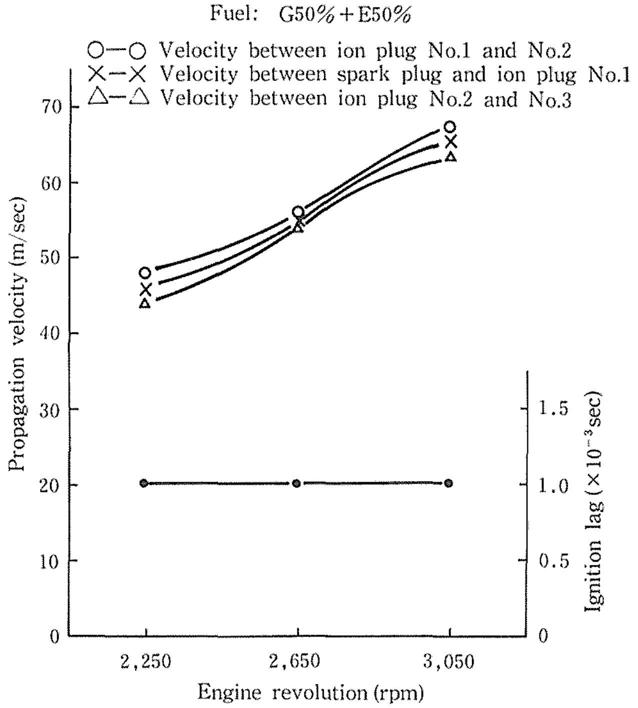

Fig. 14. Propagation velocity and ignition lag for the blend fuel of 50 % gasoline and 50 % eucalyputs oil.

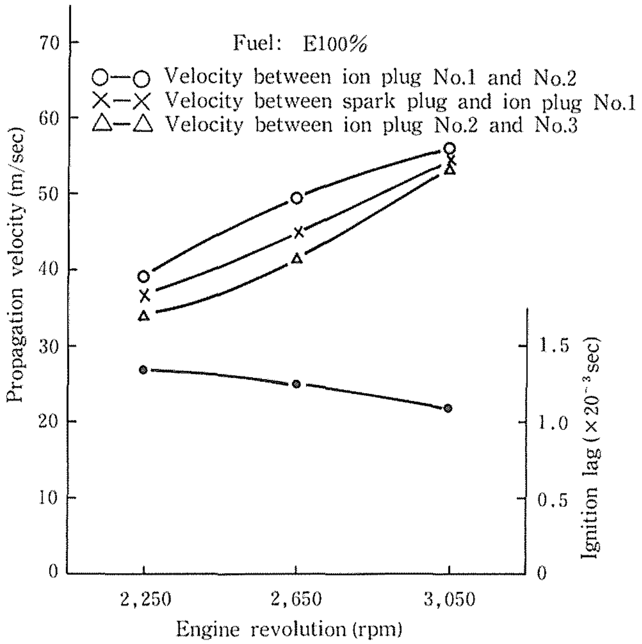

Fig. 15. Propagation velocity and ignition lag for the 100 % eucalyptus oil.

The propagation velocity was increased with the increase of the engine speed (Figs. 13, 14 and 15). This was mainly due to the increased turbulence of the mixture for the higher engine speed. The ignition lag was not changed much but somewhat decreased with the increase of the engine speed, particularly for the 100% eucalyptus oil (Fig. 15).

Conclusion

1. The flame propagation velocity of eucalyptus oil blend fuels was increased with the increase engine speed and depended upon blend ratio.
2. The flame propagation velocity was large at the center of the cylinder and small near the cylinder wall.
3. The ignition lag was slightly increased with the increase of the eucalyptus oil blended and decreased with the increase of the engine speed.
4. Further study will be needed about the effects of the eucalyptus oil blend ratio upon the air-fuel ratio which will be related to the propagation velocity.

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References

1) JIS Hand Book "Petroleum" 1980.
2) Takeda S.; Study of Eucalyptus oil and its Application to Spark Ignition Engin. The Bulletin of the Faculty of Agriculture, Mie University, No. 60 pp. 93–99, 1980.
3) Hatta K. and Asanuma T.; Internal conbustion Engine Hand Book: Asakura Shoten, 1966 (in JAPANESE).
4) Terzoni g. and R. Per F. Ancilloit; Water Tolerability of Ethanol gasoline blends; Proceedings of the International symposium on Alcohol Fuels Technology.
Vol. 1 Guaruja-sp-Brasil, Oct. 1980.
5) Nagao F.; Lectures on Internal Conbustion Engines.; Yokendo Co., Ltd. 1964 (in Japanese).
6) Liljedahi J. B. et al.; Tractors and Their Power Units.; John Wiley & Sons, New York, 1979.
7) Jones F. R.; Farm Gas Engines and Tractors.; M Graw Hill Book Company, New York, 1966.
8) Hatta k.; Introduction to Heat Engines.; Yokendo Co., Ltd. Tokyo. 1968 (in Japanese).
9) Kumagai S. and T. Sakai.; Measuring Method of Internal Combustion Engines.; Yokendo Co., Ltd. Tokyo, 1963. (in Japanese).

和 文 梗 概

ユーカリ油の火花点火機関への応用 (第4報)

竹 田 策 三・法 貴 誠

第I部(a)においては，ユーカリ油，エタノール，ガソリン混合燃料の蒸留曲線を測定した結果，$E33/A\,33/G\,34$ 混合燃料の蒸留曲線は，レギュラーガソリンの蒸留曲線に近いことが判明した。蒸留曲線の結果より判断すれば上記の混合燃料は，機関の始動性，加速性，蒸気閉塞性が良好である。次に上記混合燃料を *TEA* 0660 型単気筒2サイクルガソリン機関による，出力性能，燃費率等について測定したところ，ガソリンに遜色のないデータが得られた。

次に $E33/A\,33/G\,34$ 混合燃料に無水の状態より，試料 100 cc について 0.1 vol %の水分を加えて行き，ヘイズ状態(水分飽和状態) までの等水許容度曲線を測定したところ，前記混合燃料の等水許容度は5%であった。以上よりユーカリ油はガスホール (ガソリンにアルコールを20%程度混入したもの) の相溶剤として有効なことがわかった。

第I部(b)においては，$E33/A\,33/G34$ 混合燃料に 5 vol %の水を添加し，小型2サイクルガソリン機関で，出力性能を測定した結果，出力，燃費率は無水の状態に比較し，かえって良好であった。とくに排気中のCO含有量は，5%含水の場合，無水の場合の1/5以下に低下した。その理由は，燃料中の水分気化熱により，機関燃焼室内温度低下による，有害成分の減少と考えられる。

第II部においてユーカリ混合燃料を用いエンジン燃焼室内の火炎伝播速度を調べた。その結果火炎伝播速度はエンジン回転数の増加とともに増加し，ユーカリ油の混合割合によっても影響を受けることが判明した。また火炎速度は燃焼室の中央部で大きく燃焼室内壁に近いところでは小さくなった。着火時間遅れについてはユーカリ油が混合されると少し大きくなるが，エンジン回転数が高くなると減少傾向を示した。今後空燃比と火炎伝播速度ならびに着火遅れの関係を明らかにすることが必要と考えられる。