Studies of Eucalyptus Oil and Its Application to Spark Igition Engine, (II),

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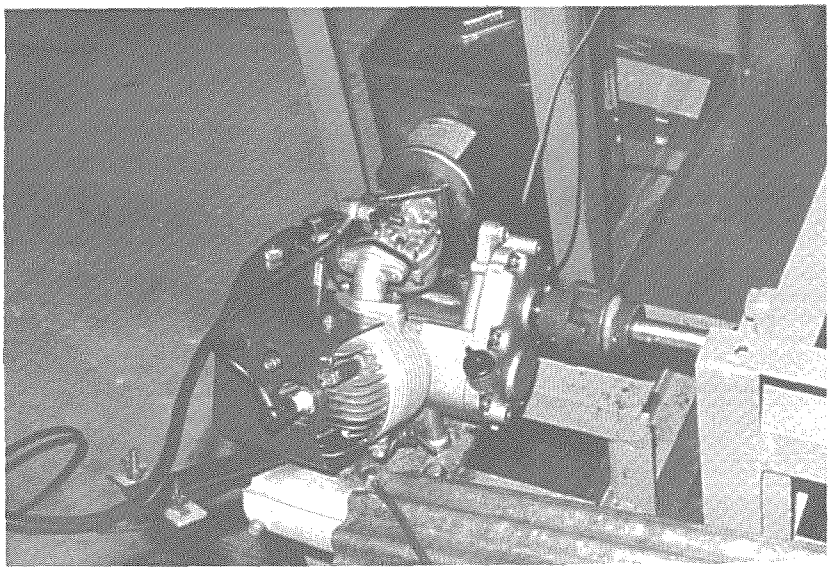

Photo 1. Two cycle engine test for Eucalyptus oil

Preface

Former paper reported on four stroke cycle engine test which was using the eucalyptus oil and its blending with gasoline for fuel.

In this paper, the authors tested eucalyptus oil for two stroke cycle engine, and the tests composed as follows.

1) Engine performance.
2) Fuel consumption rate.
3) Analysis of exhaust gas (Density of carbon monoxide).
4) Temperature of ignition plug seat, exhaust gas and so on.

1. Experimental set-up.

The specification of tested engine and other set-up are shown in Tab. 1 and Tab. 2.

Fuel and main jet nozzle of carburetter used are shown in Tab. 3.

2. Air fuel ratio of carburetter.

Fig. 1 shows the scheme of carburetter.

It consist of venturi tube, fuel nozzle with orifice, float chamber. and throttle valve choke valve.

Air is absorded through the venturi tube of piston motion. As the diameter of the throat of venturi is small, the speed of air flow becomes faster and the pressure at

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Tab. 1. Experimental Set-up and Oil

	2 rtrok cycle engine test
Tested engine model	TEA0660 (SHIBAURA)
Dynamometer	Three phase super shunt motor (TOYO DENKI SEIZO Co. Ltd.)
Fuel consumption measuring instrument (Measuring capacity)	Biuret (Multic bulb type) (10 cc)
Tachometer	Digitacho DT-201 (SHIMPO KOGYO Co. Ltd.)
Themperature measuring instrument	Digital Multi Thermometer TR-2112 (TAKEDA RIKEN Co. Ltd.)
Exhaut gas measuring instrument	Exhaut gas testor HCOT-201 (SHIMAZU SEISAKUJO Co. Ltd.)
The others	Dry-bulb thermometer Wet-bulb thermometer Barometer Stop watch
Lublicating oil	5 W-20 (KYOSEKI)

Set-up Tab. 2. Specification of TEA0660 Engine

Type	Gasoline engine of air-cooled and 2 storoke cycle type
Number of cylinder-inside diameter×stroke	1−45×38 (mm)
Total displacement	60 (cc)
Continous rated horsepower	1.8/1,660 (ps/rpm)
Maximum horsepower	2.8/2,000 (ps/rpm)
Maximum torque	1.08/1,330 (kg m/rpm)
Compression ratio	6.5
Ignition plug	B-6 HS (NGK)
Reduction gear ratio	1/3
Standard main jet nozzle diameter	0.650 (mm)
Lublicating system	Mixed lublication (Mixture ratio 25 : 1)

Tab. 3. Blendig octane number and Diameter of Main jest nozzle.

Eucalyptus oil (%)	85 octane gasoline (%)	Blending octane number	Main jet nozzle diameter (mm)
0	100	85.0	0.650
20	80	85.6	0.650
40	60	86.2	0.650
60	40	86.8	0.650 0.675
80	20	87.4	0.675 0.700
100	0	88.0	0.675 0.700 0.750

Mixed lublication (mixture ratio 25 : 1)

※Blending octane number

Bleding octnae number

$$=\frac{(\text{Octane number of gasoline}) \times (\text{Gasoline volume } \%)}{100}$$

$$+\frac{(\text{Octane number of eucalyptus oil}) \times (\text{Eucalyptus oil volume } \%)}{100}$$

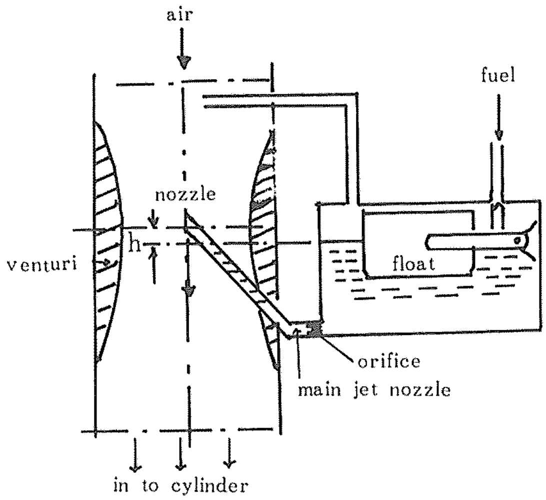

Fig. 1 Scheme of carburetter

the throut is reduced.

The pressure at the top of fuel nozzle is lower than one of float chamber, and fuel is atomized into the flow of air due to this difference of pressure.

The velocity of air flowing through the venturi tube can be determined by the follwing equation.

$$P_o - P = \frac{\gamma_a U^2}{2g}$$

$$U = \sqrt{\frac{2g}{\gamma_a}(P_o - P)}$$

where P : Pressure of venturi tube (kg/m²).

P_o : Atomospheric pressure (kg/m²).

U : Air speed of throat of venturi (m/sec).

γ_a : Specific gravity of air (kg/m³)
g : Acceleration of gravity (m/sec²)

Let A be the cross sectional area of venturi tube at the throat, Ca be flow coeficient of venturi and Ga be the air flow.

$$G_a = C_a A \sqrt{2g\ (P_o - P)/\gamma_a} \quad \cdots\cdots (1)$$

Considering the fuel flow nozzle, it can be expressed by the same equation neglection the fuel compressibity.

$$G_f = C_f A \sqrt{2g\ (P_o - P - \Delta P)/\gamma_f} \quad \cdots\cdots (2)$$

where G_f : Flow of fuel. (m³/sec).
C_f : Flow coeficient of nozzle.
A : Cross sectional area of orifice (m²).
(Main jet nozzle).
ΔP : The pressure of fuel coloumn between fuel nozzle and the level of fuel in the float chamber (kg/m²)

γ_f : Specific gravity of fuel (kg/m³)

Let AF air-fuel ratio, and it can be deriverd from the equation(1) and (2)

$$AF = \frac{G_a}{G_f} = \frac{C_A}{C_f}\sqrt{\frac{\gamma_f\ (P_o - P)}{\gamma_a\ (P_o - P - \Delta P)}}$$

Eucalyptus oil has smaller valve in theoretical air-fuel ratio than gasoline, the flow of fuel (G_f) became less, and air-fuel ratio (AF) become large.

For this reason, the flow of fuel (G_f) should be increased and air-fuel raio should be smaller than the case of gasoline.

The diameter of orifice should be larger in order to increase the flow of fuel (G_f)

3 . Experimental method.

The engine performance test was done under the full throttle condition.

1) The engine was started and warmed up for about twenty minuts until it becomes the steady state operation.

2) The throttle valve was opened fully and the load was loaded by dynamometer.

3) The followings such as horsepower, fuel consumption, exhaust gas, and temperature were measured for *various set speed of engine revolution.

4) The air pressure, dry and wet temperature, temperature and specific gravity of fuel were measured.

*Various set speed of engine revolution are shown as follows.

For two stroke cycle engine test.

3,000 3,500 4,000 4,500 5,000 5,500 6,000 (rpm)

4 . Experimental results.

Experimental results are shown from Fig. 2 to Fig. 11.

5 . Consideration

5-1 Physical and chemical properties of eucalytus oil.

The octane number of eucalyptus oil was higher than the one of gasoline, eucalyptus oil can be desirbly used for the engine of which the compression ratio is considerably high.

But flash point of eucalyptus oil was higher than the one of gasoline and was about as high as the one of light oil. This is a problem in engine starting under a low temperature condition. When the mixture ratio of eucalyptus oil to gasoline is high, it is quite difficult to directly operates the engine without pre-heating.

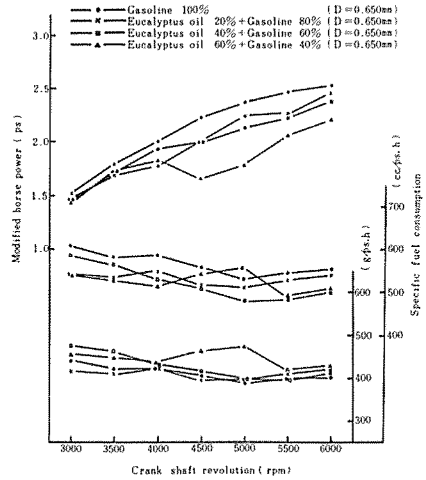

Fig. 2 2stroke cycle engine test (1)

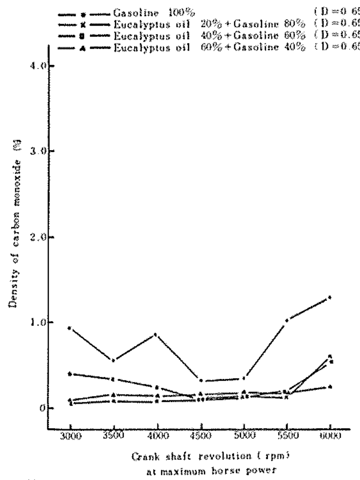

Fig. 3 2stroke cycle engine test (2)

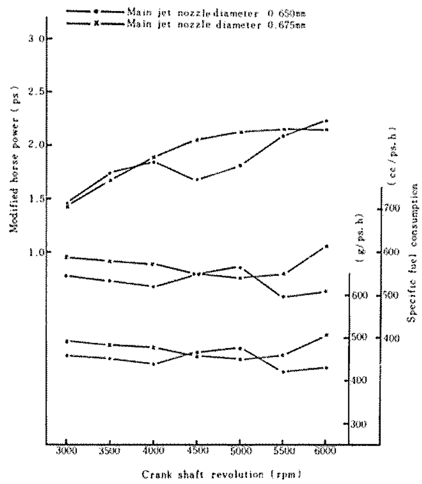

Fig. 4 2stroke cycle engine test (3)
Eucalyptus oil 60%+Gasoline40%

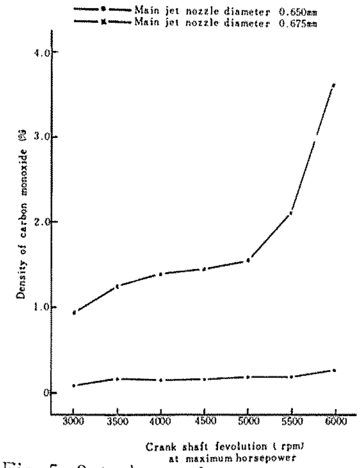

Fig. 5 2stroke cycle engine test (4)
Eucalyptus oil 60%+Gasoline40%

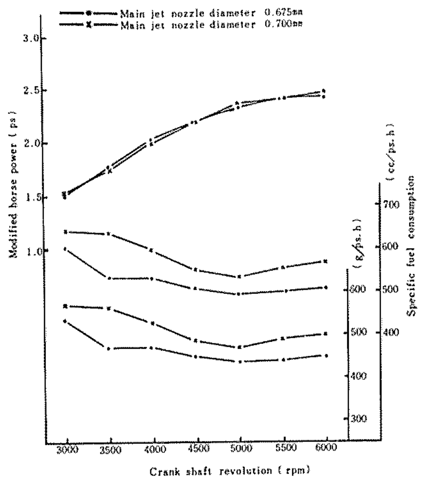

Fig. 6 2stroke cycle engine test (5)
Eucalyptus oil 80%+Gasoline20%

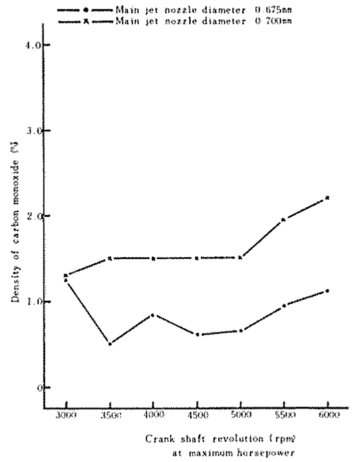

Fig. 7 2stroke cycle engine test (6)
Eucalyptus oil 80%+Gasoline20%

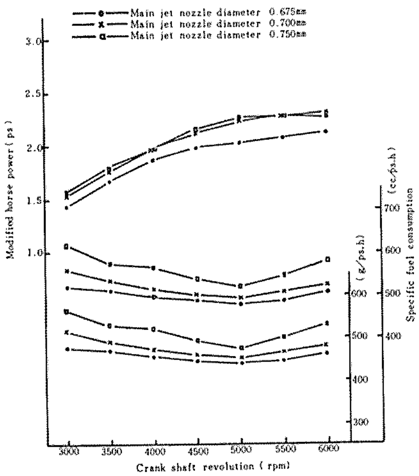

Fig. 8 2stroke cycle engine test (7)
Eucalyptus oil 100%

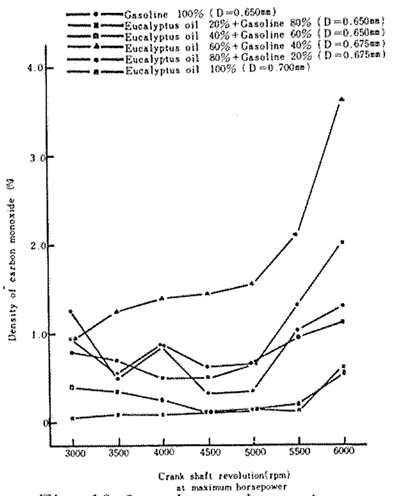

Fig. 10 2stroke cycle engine test (9)

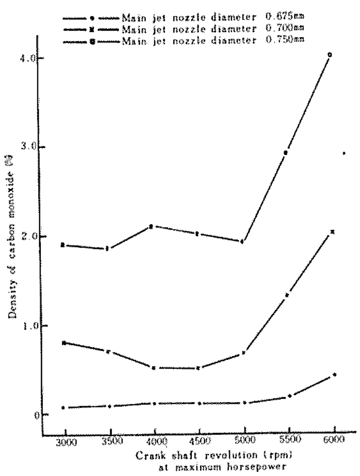

Fig. 9 2stroke cycle engine test (8)
Eucalyptus oil 100%

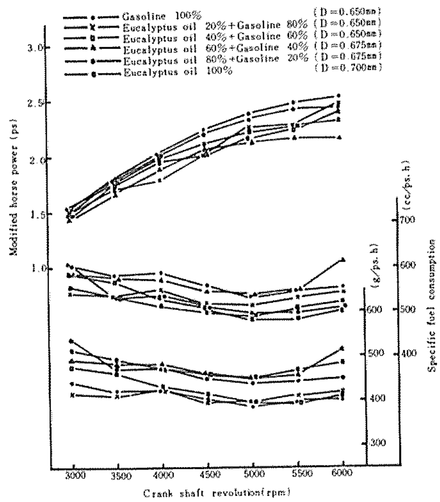

Fig. 11 2stroke cycle engine test (10)

A quantity of preformed gum in eucalyptus oil was more than the one in gasoline, too. A gummy substance is deposited in a caburetter, a main jet nozzle and a intake valve. In this experiment preformed gum was not dissolved by·n-paraffine and n-hydrocarbon but was dissolved by iso-carbon.

Viscosity of eucalyptus oil higher than the one of gasoline, too.

When the mixing ratio of the eucalyptus oil gasoline is quite high, an engine with a standard main jet nozzle can not be smoothly operated because of the higher viscosity than gasoline. A little larger size of nozzle diameter will be recommended to assure the continuous stable operation of the engine.

5-2 Two stroke cycle engine test.

1) The possible mixing ratio of eucalyptus oil to gasoline for the use of regular main jet nozzle.

One of the problems is how and by what factors the possible mixing ratio can be evaluated.

Horsepower, fuel consumptinn and exhaust gas are the factors to evaluate the posible mixing ratio, for example. From the point of save energy and pollution recently, fuel consumption and exhaust gas will be the important factors. Aa the theoretical air-fuel ratio of eucalyptus oil is smaller than gasoline and it has higher viscosity, in case of using the regular size main jet nozzle, the more the mixing ratio of eucalyptus oil, the weaker the mixing gas absorbed into combustion chamber and goes down, and fuel consumption and density of carbon monoxide become less.

In case of blended eucalyptus oil 20% and 40% with gasoline, horsepower goes down about 10%.

In case of eucalyptus oil 60%, horsepower falls suddenly at 4,500 and 5,000 rpm. In case of eucalyptus oil 80%, as horsepower falls down remarkably.

2) The comparison of mixture fuel and gasoline with a just main jet nozzle only the diameter of the orifice was considered for the main jet nozzle for better mixing ratio of the eucalyptus oil gasoline.

In 60% mixing ratio of fuel of eucalyptus oil to gasoline, the diameter of main jet nozzle was 0.650mm. The decrease of output horsepower was observed at the range of 4,000 and 4,500 rpm.

The decrease of output horsepower was not observed when a diameter of main jet nozzle of 0.675mm was used. From this the diameter of main jet nozzle would be 0.675 mm in case of using the eucalyptus oil of which the mixing ratio is 60%. In case of using the mixing ratio of 80%, almost the same output horsepower was obtained for the diameter 0.675 and 0.700mm.

When the diameter of main jet nozzle is small, the supplied quantity of fuel is decreased and the mixing gas rarefies. Therefore output horsepower, specific fuel consumption and density of carbon become lower.

When a diameter of main jet nozzle is big, the supplied quantity of fuel is increased and the mixing is condensed. So the output horsepower, specific fuel consumption and density of carbon become higher.

6. Summary

In this paper the horsepower performance by eucalyptus oil and gasoline was compared and discussed, especially on the mixing ratio of eucalyptus oil and gasoline.

The more the mixing ratio is, the higher viscosity of fuel becomes.

To cover the difficulty of fuel due to the increase of viscosity, a little larger diameter of main jet nozzle should be adopted for smooth operation. In case of using eucalyptus oil only for fuel, there exist some difficulty in engine starting under the low temperature condision.

The output horsepower by use of eucalyptus oil was 10% lower than the one of gasoline.

Eucalyptus oil will be one of the most hopeful type of energy as for internal combustion engine fuel. For the practical use of eucalyptus oil as a new type of energy resources, the further experiments will be desirably needed as follows.

1) Endurance test to investigate the wear of engine and accumulation of preformed gum.

2) A comparison the output horsepower between the experimental and the theoretical, from the view point of a calorific value and supplied quantity of fuel.

3) Two stroke cycle engine test by use of eucalyptus oil without adding the lublicating oil.

APPENDIX

(1) 2 storke sycle engine test (1)

GASOLINE 100%
Main jet nozzlc diameter 0.650mm

Grank shaft revolution (rpm)	3,000	3,500	4,000	4,500	5,000	5,500	6,000
Modified horse power (ps)	1.52	1.80	2.01	2.23	2.36 6	2.43	2.51
Fuel consumption (1 / h)	0.928	1.051	1.182	1.244	1.262	1.300	1.395
Specific fuel consumption (g/ps·h)	439	420	423	401	385	394	400
Specific fuel consumption (cc/ps·h)	610	584	588	558	535	547	556
Temperature of ignition plug (°C)	105	99	99	92	90	88	88
Temperature of exhaust gas (°C)	445	478	504	553	578	588	603
Density of carbon monoxide (%)	0.95	0.55	0.88	0.33	0.3 5	1.03	1.30
Thermal efficiency (%)	13.7	14. 3	14 2	15.0	15.6	15.3	15.1

H=769 (mmHg) DT=9.0 (℃) K=0.9607 C=10,500 (k cal/kg)
h=4.573 (mmHg) WT=5.5 (℃) G=0.7190 (15/4℃)

2) 2stroke cycle engine test (2)

EUCALYPTUS OIL 20%
GASOLIN 80%
Main jet nozzle diameter 0.650mm

Crank shaft revolution (rpm)	3,000	3,500	4,000	4,500	5,000	5,500	6,000
Modified horse power (ps)	1.47	1.70	1.78	2.00	2.24	2.26	2.45
Fuel conusmption (1 /h)	0.802	0.911	0.978	1.040	1.146	1.154 4	1.328
Spcific fuel consumption (g/ps·h)	416	409	421	397	392	407	415
Specific fuel consumption (cc/ps·h)	544	533	551	520	513	532	543
Temperature of ignition plug (°C)	92	92	88	76	76	82	80
Temperature of exhaust gas (°C)	452	473	500	540	585	590	621
Density of carbon monoxide (%)	0.06	0.09	0.08	0.10	0.14	0.13	0.60
Thermal efficiency (%)	14.9	15.1	14.7	15.6	15.8	15.2	14.9

H=769 (mmHg) DT=8.5 (°C) K=0.9602 C=10,206 (k cal/kg)
h=4.855 (mmHg) WT=5.5 (°C) G=0.7642 (15/4 °C)

3) 2stroke cycle engine test (3)

EUCALYPTUS OIL 40%
GASOLINE 60%
Main jet nozzle diameter 0.650mm

Crank shaft revolution (rpm)	3,000	3,500	4,000	4,500	5,000	5,500	6,000
Modified horse power (ps)	1.46	1.73	1.94	2.00	2.13	2.23	2.38
Fuel consumption (l/h)	0.859	0.986	1.034	1.020	1.034	1.081	1.204
Specific fuel consumption (g/ps·h)	476	461	431	413	393	392	409
Specific fuel consumption (cc/ps·h)	588	570	533	510	485	485	506
Temperature of ignition plug (°C)	8 2	96	92	81	75	75	77
Temperature of exhaust gas (°C)	448	485	525	544	563	599	635
Density of carbon monoxide (%)	0.40	0.35	0.25	0.11	0.15	0.19	0.55
Thermal efficiency (%)	13.4	13.8	14.8	15.4	16.2	16.2	15.5

H=756 (mmHg) DT=9.8 (°C) K=0.9800 C=9,941 (Kcal/kg)
h=5.277 (mmHg) WT=6.6 (°C) G=0.8092 (15/4°C)

4) 2stroke cycle engine test (4)

EUCALYPTUS OIL 60%
GASOLINE 40%
Main jet nozzle diameter 0.650mm

Crank shaft revolution (rpm)	3,000	3,500	4,000	4,500	5,000	5,500	6,000
Modified horse power (ps)	1.46	1.74	1.85	1.67	1.81	2.09	2.22
Fuel consumption (l/h)	0.795	0.930	0.960	0.918	1.020	1.037	1.129
Specific fuel consumption (g/ps·h)	459	451	438	464	475	419	429
Specific fuel consumption (cc/ps·h)	545	534	519	550	564	496	509
Temperature of ignition plug (°C)	92	94	89	85	80	78	80
Temperature of exhaust gas (°C)	449	492	519	512	555	587	628
Density of carbon monoxide (%)	0.09	0.17	0.15	0.16	0.19	0.19	0.26
Thermal efficiency (%)	14.2	14.5	14.9	14.0	13.7	15.6	15.2

H=756 (mmHg) DT=10.5 (°C) K=0.9816 C=9.701 (K cal/kg)
h=5.835 (mmHg) WT=7.5 (°C) G=0.8435 (15/4°C)

5) 2stroke cycle engine test (5)

EUCALYPTUS OIL 60%
GASOLINE 40%
Main jet nozzle diameter 0.675mm

Crank shaft revolution (rpm)	3,000	3,500	4,000	4,500	5,000	5,500	6,000
Modified horse power (ps)	1.44	1.68	1.88	2.05	2.12	2.14	2.14
Fuel consumption (l/h)	0.851	0.976	1.081	1.129	1.143	1.180	1.314
Specific fuel consumption (g/ps·h)	493	484	479	459	450	459	512
Specific fuel consumption (cc/ps·h)	591	581	575	551	540	551	614
Temperature of ingition plug (°C)	94	92	88	86	82	80	80
Temperature of exhaust gas (°C)	441	473	503	540	569	582	592
Density of carbon monoxide (%)	0.95	1.25	1.40	1.45	1.55	2.10	3.60
Thermal efficiency (%)	13.2	13.5	13.6	14.2	14.5	14.2	12.7

H=764 (mmHg) DT=9.5 (°C) K=0.9682 C=9,701 (k cal/kg)
h=4.810 (mmHg) WT=6.0 (°C) G=0.8335 (15/4°C)

6) 2stroke cycle engine test (6)

EUCALYPTUS OIL 80%
GASOLINE 20%
Main jet nozzle diameter 0.675mm

Crank shaft revolution (rpm)	3,000	3,500	4,000	4,500	5,000	5,500	6,000
Modified horse power (ps)	1.50	1.77	2.02	2.19	2.32	2.40	2.42
Fuel consumption (l/h)	0.911	0.945	1.081	1.115	1.147	1.196	1.229
Specific fuel consumption (g/ps·h)	537	471	473	449	436	440	448
Specific fuel consumption (cc/ps·h)	608	534	535	509	494	498	508
Temperature of ignition plug (°C)	97	98	96	92	87	83	83
Temperature of exhaust gas (°C)	422	475	505	540	571	581	610
Density of carbon monoxide (%)	1.25	0.50	0.87	0.62	0.65	0.95	1.12
Thermal efficiency (%)	12.4	14.2	14.1	14.8	15.3	15.2	14.9

H=756.5 (mmHg) DT=10 5 (°C) K=0.9809 C=9,483 (k cal/kg)
h=5.834 (mmHg) WT=7.5 (°C) G=0.8830 (15/4°C)

7) 2stroke cycle engine test (7)

EUCALYPTUS OIL 80%
GASOLINE 20%
Main jet nozzle diameter 0.700mm

Crank shaft revolution (rpm)	3,000	3,500	4,000	4,500	5,000	5,500	6,000
Modified horse power (ps)	1.53	1.77	2.00	2.19	2.37	2.40	2.45
Fuel consumption (l/h)	0.989	1.132	1.200	1.208	1.263	1.333	1.390
Specific fuel consumption (g/ps·h)	571	565	530	487	471	491	501
Specific fuel consumption (cc/ps·h)	646	640	600	552	533	556	567
Temperature of ignition plug (°C)	93	95	92	89	90	81	80
Temperature of exhaust gas (°C)	414	447	483	516	547	460	581
Density of carbon monoxide (%)	1.30	1.50	1.50	1.50	1.50	1.95	2.20
Thermal efficiency (%)	11.7	11.8	12.6	13.7	14.2	13.6	13.3

H=756 (mmHg) DT=10.5 (°C) K=0.9816 C=9,483 (k cal/kg)
h=5.835 (mmHg) WT=7.5 (°C) G=0.8830 (15/4°C)

8) 2stroke cycle engine test (8)

EUCALYPTUS OIL 100%
Main jet nozzle diameter 0.675mm

Crank shaft revolution (rpm)	3,000	3,500	4,000	4,500	5,000	5,500	6,000
Modified horse power (ps)	1.42	1.66	1.86	1.97	2.01	2.06	2.11
Fuel conusmption (l/h)	0.738	0.849	0.923	0.960	0.963	1.000	1.065
Specific fuel consumption (g/ps·h)	476	468	455	446	439	445	462
Specific fuel consumption (cc/ps·h)	520	512	496	487	479	485	505
Temperature of ignition plug (°C)	80	82	82	78	78	77	77
Temperature of exhaust gas (°C)	449	491	528	558	585	612	647
Density of carbon monoxide (%)	0.06	0.07	0.10	0.10	0.10	0.16	0.40
Thermal efficiency (%)	14.3	14.6	15.0	15.3	15.5	15.3	14.7

H=764 (mmHg) DT=9.0 (°C) K=0.9677 C=9,283 (k cal/kg)
h=5.092 (mmHg) WT=6.0 (°C) G=0.9157 (15/4°C)

9) 2stroke cycle engine test (9)

EUCALYPTUS OIL 100%
Main jet nozzle diameter 0.700mm

Crank shaft revolution (rpm)	3,000	3,500	4,000	4,500	5,000	5,500	6,000
Modified horse power (ps)	1.53	1.77	1.97	2.11	2.21	2.25	2.30
Fuel consumption (l/h)	0.861	0.947	1.014	1.056	1.088	1.147	1.204
Specific fuel conusmption (g/ps·h)	516	490	472	458	451	465	480
Sqecific fuel consumption (cc/ps·h)	563	535	515	500	492	507	523
Temperature of ignition plug (°C)	94	90	87	84	82	80	78
Temperature of exhaust gas (°C)	445	480	521	555	586	593	612
Density of carbon monoxide (%)	0.80	0.70	0.50	0.50	0.65	1.30	2.00
Thermal efficiency (%)	13.2	13.9	14.4	14.9	15.1	14.6	14.2

H=765 (mmHg) DT=9.0 (°C) K=0.9658 C=9,283 (k cal/kg)
h=4.583 (mmHg) WT=5.5 (°C) G=0.9161 (15/4°C)

10) 2stroke cycle engine test (10)

EUCALYPTUS OIL 100%
Main jet nozzle diameter 0.750mm

Crank shaft revolution (rpm)	3,000	3,500	4,000	4,500	5,000	5,500	6,000
Modified horse power (ps)	1.55	1.79	1.96	2.14	2.25	2.26	2.26
Fuel consumptin (l/h)	0.957	1.032	1.115	1.150	1.165	1.233	1,309
Specific fuel consumption (g/ps·h)	566	528	521	492	474	500	530
Specific fuel consumption (cc/ps·h)	618	576	569	538	518	546	579
Temperature of ignition plug (°C)	89	88	82	84	79	77	75
Temperature of exhaust gas (°C)	426	469	498	529	554	564	579
Density of carbon monoxide (%)	1.90	1.85	2.10	2.00	1.90	2.90	4.00
Thermal efficiency (%)	12.0	12.9	13.1	13.8	14.4	13.6	12.9

H=767 (mmHg) DT=8.0 (°C) K=0.9616 C=9,283 (k cal/kg)
h=4.639 (mmHg) WT=5.0 (°C) G=0.9157 (15/4°C)

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摘　　要

ユーカリ油の火花点火機関への応用(II)

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前論文において、ユーカリ油の燃料としての分析を行ない，これが火花点火機関の代替燃料として極めて優れていることを明らかにし，M社製F25L単気筒空冷4サイクル機関による出力，燃費率および排気分析を行なった。第2報では，S社製ＴＥＡＯ 660単気筒空冷2サイクル機関による実験の結果，ユーカリ油単体およびユーカリ油混合燃料はガソリンに比較し，機関出力，燃費率とも大きな差は認められなかった。

ユーカリ混合燃料による最大トルク附近の排気分析の結果ＣＯ濃度は，ユーカリ油混入量に比例して減少した。

ユーカリ油40%をガソリンに混入すれば，排気中のＣＯ濃度は⅓以下に減少した。

ユーカリ油は実在ガムが、ガソリンにくらべ非常に多い，すなわちユーカリ油の実在ガム47.2mg／100ccにくらべガソリンは5mg/100cc以下である。燃料中のガム質は機関吸入系の堆積物生成および，機関燃焼室の汚損などが懸念されるが，ガソリンあるいはアルコール混入物として使用すれば影響が少いと考えられるも今後の実験で、これを確める必要がある。