Orange Oil and Its Application to Spark Ignition Engine

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Summary

Orange oil can be extracted from the peel of citrus. In Japan the production of orange oil as about 2000 tons per year. However, no orange oil has been used for any specific purpose.

The main ingredient of orange oil consists of d-limonen.

About 0.6-1.0% oil can be extracted from the peel of "Unshu orange", which is a kind of typical Japanese tangerine.

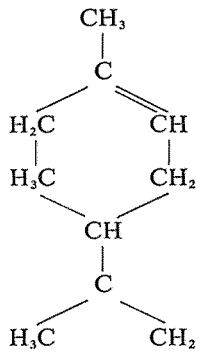
Orange oil has 106-140 research octane number which is good for runing the CER engine.

The flash point of orange oil measured by Pensky-Martens method was at 56°C. In the use of orange oil only as fuel without blending, some difficulty was found in engine startability under cold conditions.

1 Properties of Orange Oil

Orange oil can be extracted from the peel of citrus at normal temperature. It is obtained as a by-product during the process of producing juice, by use of the in-line system which is called C. P. O. (Cold Pressed Oil).

The yield of extracted C. P. O. is about 0.2-0.5% of total weight of citrus. The main gredient of C. P. O. (Orange oil) is d-limonen ($C_{10}H_{16}$) of which chemical structure is shown as follows.



2 Physical Properties of the Orange Oil

Table 1 shows the physical properties of the orange oil tested. In general, orange oil has high octane value enough to run the CFR engine.

The flash point of the orange oil measured by the Pensky Martens method was in the range of 54-56°C. Some difficulty was found in startability especially under the cold weather condition.

3 Distilation Curves of the Orange Oil

Fig. 1 shows the distillation curves for the gasoline, orange oil and their blended fuels. The initial

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Table 1. Properties of orange oil.

Item \ Sample No.	Orange oil No. 1	Orange oil No. 2	Orange oil No. 3	Orange oil No. 4
Specific gravity 15/4°C	0.8467	0.8450	0.854	0.845
Flash point by P.M. method	56	54	56	54
Calorific value Cal/kg	—	10814	—	—
Viscosity 30°C/cst	0.99	0.95 (25°C/cst)	1.05	0.939
Octane value (R.O.N.)	137.7	140	106	135

distillation point was 175°C for d-limonen (Orange oil) and 45°C for gasoline.

The distillation characteristics of 10% orange oil blended with gasoline showed the value nearly equal to the pure gasoline. The blended fuel of 10% orange oil with gasoline is expected to have good startability, better acceleration and less vapor lock tendency, which are desirable for the spark ignition engine.

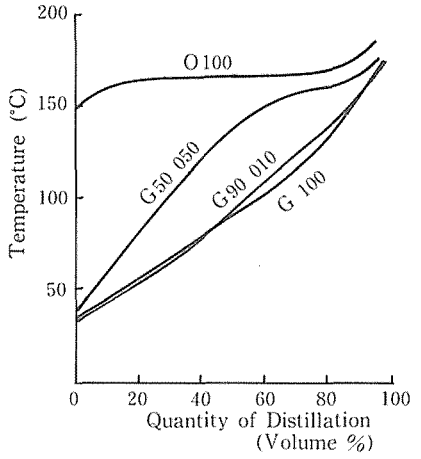

Fig. 1. Distillation curve of the orange oil

Table 2. Specifications of the engine tested.

Type	Gasoline engine with air cooled two stroke cycle
Model	TEA0660
Number of cylinder	One cylinder
bore × stroke m/m	45 × 38
Capacity	60 c.c.
Continuous rated PS	1.8 ps/1660 r.p.m.
Maximum horse power	2.8 PS/2000 r.p.m.
Maximum torque	1.08 kg.m/1330 r.p.m.

4 Two Stroke Cycle Engine Test

Tab. 2 shows the specifications of engine model TEAO660. This type of engine is normally used for the garden tractor and the rice transplanter in Japan.

Fig. 2 shows the engine performance and the specific consumption of fuels with various blending ratio. The use of the blending fuel of 10% orange oil with gasoline increased the engine performance than the case of gasoline only.

Fig. 3 shows the carbon monoxide and hydrocarbon contained in the emission gas. The addition of orange oil into gasoline could reduce about a half volume of hydrocarbon content in the emission gas.

5 Isowater Tolerance Line of Orange Oil

Fig. 4 shows the isowater tolerance lines of Gasoline-Orange oil-Ethanol. In case of no water existence in the fuel. Three kinds of blended fuel has good mixingability on each other.

Orange oil has less isowater tolerance than eucalyptus oil. The case of 33% ethanol, 33% of orange oil and 34% gasoline blended fuels, that the isowater toletance line should be 2% only.

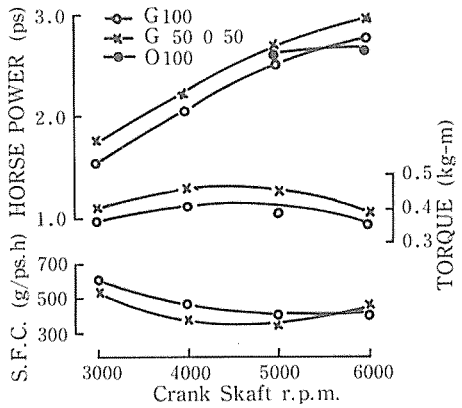

Fig. 2. Engine performance.

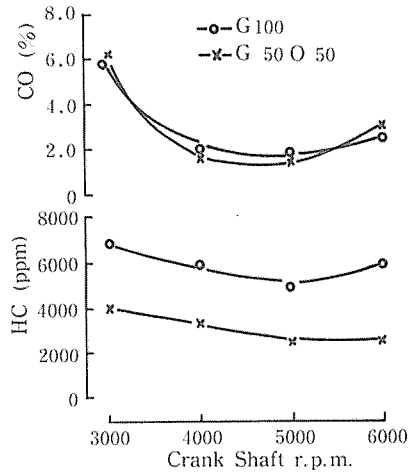

Fig. 3. Variation of CO and HC in the exhaust gas.

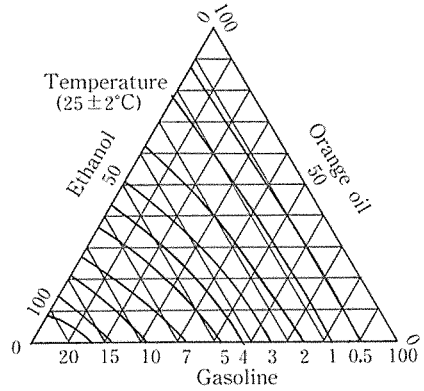

Fig. 4. Isowater tolerance lines for system; Gasolin-Orange oil — Ethanol.

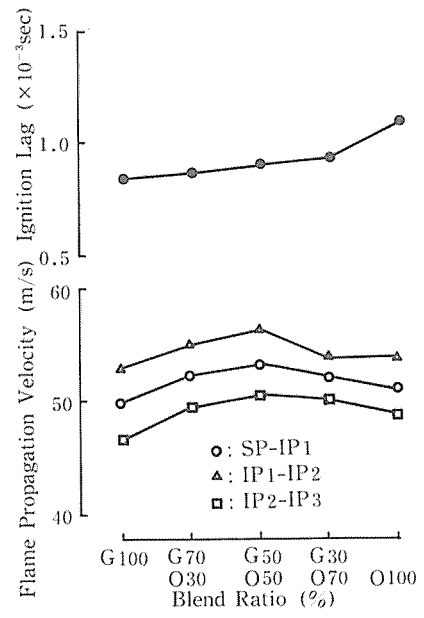

Fig. 5. Flame propagation velocity for G700 engine.

6 Flame Propagation Velocity of the Blend Fuel of Orange Oil

The flame propagation velocity of the blended fuels of orange oil was measured by the using of ion plug installation method. Three ion plugs 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 current was caused between the electrodes.

The time required for the flame to travel from the spark plug to an ion plug also between the ion plug was obtained on an oscilloscope.

The flame propagation velocity between the spark plug and the ion plug No. 1 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 the avarage velocity between the ion plug No. 1 and No. 3.

Fig. 5 shows the flame propagation velocity for G700 four stroke cycle air cooled engine at the crankshaft revolution is 3050 r. p. m.

7 Automobile Enging Test

Table 3 shows the specification of the two stroke engine used in this tests. Engine performance showed the result nearly equal to the gasoline. (Fig. 6)

Hydrocarbon contained in exhaust gas was was slightly reduced than gasoline in case of the orange oil used.

Nox in exhaust gas showed about 50% decrease as compared to the gasoline only usage. It was attributed to the higher velocity of flame propagation than gasoline. (Fig. 7)

Table 3. Specification of engine.

Model	T5B-(V) Water cooled 2 stroke cycle
bore stroke No. of Cylinder	61.0^{mm} × 61.5^{mm} × 3
Piston displacement	539 cc
Max. horse power	28 ps/5500 r.p.m.
Max. torque	5.3 kg.m/3000 r.p.m.
Compression ratio	7.0

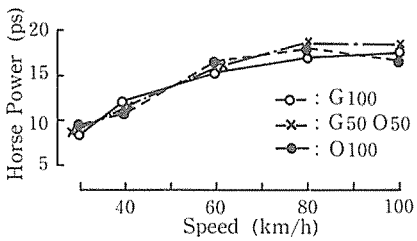

Fig. 6. 2 Stroke-cycle bench test result.

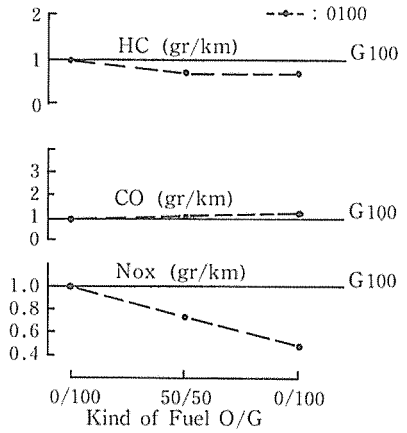

Fig. 7. Variation of CO and NOX in the exhaust gas (2 Stroke cycle engine).

Conclusion

a) Distillation cure of the 10% orange oil blended fuel showed almost the same characteristics as gasoline.

b) Engine performance showed similar horsepower for both fuels, and specific fuel consumption showed also the nearly equal results.

c) The orange oil fuel showed the higher flame propagation velocity than gasoline.

d) The octane number of the orange oil showed 106-140. It can be used as one of the octane booster additive by blening in to the lower octane fuels.

References

a) Sakuzo TAKEDA; An eucalyptus experiment; Proceedings of the IV International Symposium on Alcohol

fuels Technology. Guaruja-Sp-Brasil, 5-8 Oct. 1980.
b) Sakuzo TAKEDA; Studies of eucalyptus oil and its application to spark ignition engine; International Conference on Agricultural Engineering and Agro-Industries in Asia. 10-13 Nov. 1981. Asian Institute of Technology, Bangkok.
c) Sakuzo TAKEDA; Studies of eucalyptus oil and their application to Internal combustion engine; Pan-Pacific Synfuel Conference Tokyo '82, Nov. 17-19, 1982. Tokyo, Japan.
d) Sakuzo TAKEDA; Orange oil and its application to Spark ignition engine; American Society of Agricultural Engineering, Winter Meeting, Chicago, 1982, Dec.

梗　　概

オレンジ油燃料とその火花点火機関への利用

竹　田　策　三

オレンジ油は「柑きつ類」の外皮に含まれ，インライン搾汁プラントを有するジュース工場の副産物として得られる。わが国における柑きつ類（温州みかんが大部分を占めている）約350万 t のうち，加工用は約100万 t，これより採れるオレンジ油は 2000 t が可能である（賦存量）。オレンジ油の主成分は d-limonen ($C_{10}H_{16}$) で，果実よりの得率は0.2-0.5%である。

本研究はオレンジ油およびオレンジ油をガソリンに混入し，小型２サイクル農用機関を用い，機関出力，燃費率，排気分析，火炎伝播速度および，シヤシーダイナモメータによる軽四輪車の機関出力，排気分析を行なった結果，機関出力，燃費率に大きな差はなかった。また排気中の未燃焼炭化水素分はオレンジ油の混入に比例して減少した。火炎伝播速度はオレンジ油の混入によりガソリンより速くなった。オレンジ油のオクタン価は 106-140で，低オクタン燃料のオクタン価向上剤として利用可能である。