US 20220228078A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2022/0228078 A1**

OBATA et al. (43) **Pub. Date: Jul. 21, 2022**

(54) **FUEL COMPOSITION FOR LEAN BURN ENGINE**

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(21) Appl. No.: **17/609,523**

(22) PCT Filed: **Jul. 17, 2020**

(86) PCT No.: **PCT/JP2020/027879**

§ 371 (c)(1),
(2) Date: **Nov. 8, 2021**

(30) **Foreign Application Priority Data**

Jul. 31, 2019 (JP) 2019-140862

Publication Classification

(51) **Int. Cl.**
C10L 1/06 (2006.01)

(52) **U.S. Cl.**
CPC ***C10L 1/06*** (2013.01)

(57) **ABSTRACT**

A fuel composition for a lean burn engine comprising hydrocarbons having 4 to 6 carbon atoms as main component, with an aromatic content of 25 vol % or less.

FUEL COMPOSITION FOR LEAN BURN ENGINE

TECHNICAL FIELD

[0001] The present invention relates to a fuel composition for a lean burn engine.

BACKGROUND ART

[0002] Conventionally, a lean burn engine that burns fuel in an air-fuel mixture leaner than the theoretical air-fuel ratio has been known. As a fuel for the lean burn engine, for example, in Patent Literature 1, a fuel composition for a lean burn engine including one or more types of gasoline selected from the group consisting of alkylate gasoline, catalytically reformed gasoline, light catalytic cracking gasoline, and coker light gasoline is disclosed.

CITATION LIST

Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Publication No. 2007-182579

SUMMARY OF INVENTION

Technical Problem

[0004] In a lean burn engine, the upper limit of operable air-fuel ratio (air/fuel) is referred to as lean limit, and through expansion of the lean limit, improvement in fuel efficiency and stabilization of combustion are expected.

[0005] An object of the present invention is to provide a fuel composition for a lean burn engine capable of expanding the lean limit of a lean burn engine.

Solution to Problem

[0006] One aspect of the present invention relates to a fuel composition for a lean burn engine, which comprises hydrocarbons having 4 to 6 carbon atoms as main component, with an aromatic content of 25 vol % or less.

[0007] In an aspect, the content of olefins having 4 to 6 carbon atoms may be 20 to 60 vol % relative to the total amount of hydrocarbons having 4 to 6 carbon atoms.

[0008] In an aspect, the content of normal paraffins having 4 to 6 carbon atoms may be 20 vol % or less relative to the total amount of hydrocarbons having 4 to 6 carbon atoms.

[0009] In an aspect, the content of hydrocarbons having 4 to 6 carbon atoms may be 85 vol % or more.

Advantageous Effect of Invention

[0010] According to the present invention, a fuel composition for a lean burn engine capable of expanding the lean limit of a lean burn engine is provided.

DESCRIPTION OF EMBODIMENT

[0011] A preferred embodiment of the present invention will be described in detail below.

[0012] The fuel composition of the present embodiment is a fuel composition that comprises hydrocarbons having 4 to 6 carbon atoms as main component (for example, 50 vol % or more, preferably 60 vol % or more, more preferably 70 vol % or more, still more preferably 80 vol % or more, and further preferably 85 vol % or more).

[0013] In the present embodiment, the aromatic content in the fuel composition is 25 vol % or less, preferably 20 vol % or less, more preferably 15 vol % or less, still more preferably 10 vol % or less, further preferably 5 vol % or less, furthermore preferably 3 vol % or less, and particularly preferably 2 vol % or less.

[0014] The fuel composition of the present embodiment comprises hydrocarbons having 4 to 6 carbon atoms as main component with an aromatic content equal to or less than a specific value to expand the lean limit of a lean burn engine, being suitable for use as a fuel composition for a lean burn engine (in particular, for use in ultra-lean burn with a lean limit of 2 or more).

[0015] In the present specification, the content of each component in the fuel composition is a value measured by the method described in JIS K 2536-2 "Liquid petroleum products-testing method of components, Part 2: Determination of total components by gas chromatography".

[0016] The aromatic content of the fuel composition may be, for example, 0.1 vol % or more, or may be 0.5 vol % or more. By containing a slight amount of aromatic compound, the effect of further increasing the heating value per volume while suppressing knocking can be obtained.

[0017] More specifically, the aromatic content of the fuel composition may be 0.1 to 25 vol %, 0.1 to 20 vol %, 0.1 to 15 vol %, 0.1 to 10 vol %, 0.1 to 5 vol %, 0.1 to 3 vol %, 0.1 to 2 vol %, 0.5 to 25 vol %, 0.5 to 20 vol %, 0.5 to 15 vol %, 0.5 to 10 vol %, 0.5 to 5 vol %, 0.5 to 3 vol %, or 0.5 to 2 vol %.

[0018] In the hydrocarbons having 4 to 6 carbon atoms, for example, normal paraffins having 4 to 6 carbon atoms, isoparaffins having 4 to 6 carbon atoms, olefins having 4 to 6 carbon atoms, and an aromatic compound having 6 carbon atoms (benzene) may be included.

[0019] In the fuel composition of the present embodiment, the content of normal paraffins having 4 to 6 carbon atoms may be, for example, 30 vol % or less, preferably 20 vol % or less, and more preferably 15 vol % or less, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms. Thereby, the effect described above tends to be obtained more remarkably.

[0020] The content of normal paraffins having 4 to 6 carbon atoms may be, for example, 0.5 vol % or more, or may be 1 vol % or more, preferably 5 vol % or more, and still more preferably 10 vol % or more, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms. Thereby, the effect described above tends to be obtained more remarkably.

[0021] More specifically, the content of normal paraffins having 4 to 6 carbon atoms may be 0.5 to 30 vol %, 0.5 to 20 vol %, 0.5 to 15 vol %, 1 to 30 vol %, 1 to 20 vol %, 1 to 15 vol %, 5 to 30 vol %, 5 to 20 vol %, 5 to 15 vol %, 10 to 30 vol %, 10 to 20 vol %, or 10 to 15 vol %, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms.

[0022] In the fuel composition of the present embodiment, the content of isoparaffins having 4 to 6 carbon atoms may be, for example, 20 vol % or more, preferably 25 vol % or more, more preferably 30 vol % or more, and still more preferably 35 vol % or more, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms. Thereby, the effect described above tends to be obtained more remarkably.

[0023] Also, the content of isoparaffins having 4 to 6 carbon atoms may be, for example, 80 vol % or less, preferably 75 vol % or less, and more preferably 70 vol % or less, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms. The content of isoparaffins having 4 to 6 carbon atoms may be 60 vol % or less, 50 vol % or less, or 45 vol % or less, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms. Thereby, the effect described above tends to be obtained more remarkably.

[0024] More specifically, the content of isoparaffins having 4 to 6 carbon atoms may be 20 to 80 vol %, 20 to 75 vol %, 20 to 70 vol %, 20 to 60 vol %, 20 to 50 vol %, 20 to 45 vol %, 25 to 80 vol %, 25 to 75 vol %, 25 to 70 vol %, 25 to 60 vol %, 25 to 50 vol %, 25 to 45 vol %, 30 to 80 vol %, 30 to 75 vol %, 30 to 70 vol %, 30 to 60 vol %, 30 to 50 vol %, 30 to 45 vol %, 35 to 80 vol %, 35 to 75 vol %, 35 to 70 vol %, 35 to 60 vol %, 35 to 50 vol %, or 35 to 45 vol %, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms.

[0025] In the fuel composition of the present embodiment, the content of olefins having 4 to 6 carbon atoms may be, for example, 5 vol % or more, preferably 10 vol % or more, more preferably 20 vol % or more, and still more preferably 25 vol % or more, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms. Also, the content of olefins having 4 to 6 carbon atoms may be 30 vol % or more, 35 vol % or more, or 40 vol % or more, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms. Thereby, the effect described above tends to be obtained more remarkably.

[0026] Also, the content of olefins having 4 to 6 carbon atoms may be, for example, 70 vol % or less, preferably 65 vol % or less, more preferably 60 vol % or less, still more preferably 55 vol % or less, further preferably 50 vol % or less, and furthermore preferably 45 vol % or less, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms. Thereby, the effect described above tends to be obtained more remarkably.

[0027] More specifically, the content of olefins having 4 to 6 carbon atoms may be 5 to 70 vol %, 5 to 65 vol %, 5 to 60 vol %, 5 to 55 vol %, 5 to 50 vol %, 5 to 45 vol %, 10 to 70 vol %, 10 to 65 vol %, 10 to 60 vol %, 10 to 55 vol %, 10 to 50 vol %, 10 to 45 vol %, 20 to 70 vol %, 20 to 65 vol %, 20 to 60 vol %, 20 to 55 vol %, 20 to 50 vol %, 20 to 45 vol %, 25 to 70 vol %, 25 to 65 vol %, 25 to 60 vol %, 25 to 55 vol %, 25 to 50 vol %, 25 to 45 vol %, 30 to 70 vol %, 30 to 65 vol %, 30 to 60 vol %, 30 to 55 vol %, 30 to 50 vol %, 30 to 45 vol %, 35 to 70 vol %, 35 to 65 vol %, 35 to 60 vol %, 35 to 55 vol %, 35 to 50 vol %, 35 to 45 vol %, 40 to 70 vol %, 40 to 65 vol %, 40 to 60 vol %, 40 to 55 vol %, 40 to 50 vol %, or 40 to 45 vol %, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms.

[0028] In the fuel composition of the present embodiment, the total amount of normal paraffins having 4 to 6 carbon atoms, isoparaffins having 4 to 6 carbon atoms and olefins having 4 to 6 carbon atoms is, for example, 50 vol % or more, preferably 70 vol % or more, more preferably 80 vol % or more, still more preferably 90 vol % or more, and further preferably 93 vol % or more, relative to the total amount of hydrocarbons having 4 to 6 carbon atoms. Thereby, the effect described above tends to be obtained more remarkably.

[0029] The fuel composition of the present embodiment may contain hydrocarbons having more than 6 carbon atoms. The hydrocarbons having more than 6 carbon atoms may be, for example, hydrocarbons having 7 to 15 carbon atoms, or may be hydrocarbons having 7 to 10 carbon atoms.

[0030] In the fuel composition of the present embodiment, the content of hydrocarbons having more than 6 carbon atoms may be, for example, less than 50 vol %, preferably 40 vol % or less, more preferably 30 vol % or less, still more preferably 20 vol % or less, and further preferably 15 vol % or less, relative to the total amount of the fuel composition.

[0031] In the fuel composition of the present embodiment, the ratio of hydrocarbons having 4 to 6 carbon atoms relative to the total amount of hydrocarbons is, for example, 50 vol % or more, preferably 60 vol % or more, more preferably 70 vol % or more, still more preferably 80 vol % or more, further preferably 85 vol % or more, and furthermore preferably 90 mass % or more. Also, the ratio of hydrocarbons having 4 to 6 carbon atoms relative to the total amount of hydrocarbons may be 100 vol % or less, 98 vol % or less, or 95 vol % or less.

[0032] More specifically, the ratio of hydrocarbons having 4 to 6 carbon atoms relative to the total amount of hydrocarbons may be 50 to 100 vol %, 50 to 98 vol %, 50 to 95 vol %, 60 to 100 vol %, 60 to 98 vol %, 60 to 95 vol %, 70 to 100 vol %, 70 to 98 vol %, 70 to 95 vol %, 80 to 100 vol %, 80 to 98 vol %, 80 to 95 vol %, 85 to 100 vol %, 85 to 98 vol %, 85 to 95 vol %, 90 to 100 vol %, 90 to 98 vol %, or 90 to 95 vol %.

[0033] The fuel composition of the present embodiment may further contain oxygen-containing compounds.

[0034] The oxygen-containing compounds are organic compounds containing oxygen as a constituent element. Examples of the oxygen-containing compounds include oxygen-containing heterocyclic compounds, oxygen-containing aromatic compounds, and oxygen-containing aliphatic compounds. One of the oxygen-containing compounds may be used alone, or two or more thereof may be used in combination.

[0035] The oxygen-containing heterocyclic compounds are compounds having an oxygen-containing heterocycle. Examples of the oxygen-containing heterocyclic compounds include compounds having an oxygen-containing heterocycle such as a furan ring, a tetrahydrofuran ring, an ethylene oxide ring, a propylene oxide ring, a pyran ring, a tetrahydropyran ring, a benzofuran ring, and a benzopyran ring. As the oxygen-containing heterocyclic compounds, compounds having a furan ring are preferred from the viewpoint of obtaining the effect described above more remarkably. Examples of the compounds having a furan ring include furan, 2-methylfuran and 2,5-dimethylfuran. As the compounds having a furan ring, furan and 2-methylfuran are particularly preferred.

[0036] Oxygen-containing aromatic compounds are compounds that contain oxygen as a constituent element and have an aromatic ring. Examples of the oxygen-containing aromatic compounds include aromatic compounds having an oxygen atom directly bonded to an aromatic ring (for example, alkoxybenzene, phenols). Examples of alkoxybenzene include anisole, phenetol, and propyloxybenzene. As alkoxybenzene, anisole and phenetol are preferred from the viewpoint of the range of boiling point.

[0037] Examples of the oxygen-containing aliphatic compounds include alcohols, ethers (for example, ethyl alcohol, isobutyl alcohol, ETBE (ethyl-tert-butyl ether)).

[0038] In the fuel composition of the present embodiment, the content of the oxygen-containing compound may be, for

example, less than 50 vol %, preferably 40 vol % or less, more preferably 30 vol % or less, and still more preferably 25 vol % or less relative to the total amount of the fuel composition.

[0039] In the case where the fuel composition of the present embodiment contains an oxygen-containing compound, the content thereof may be, for example, 1 vol % or more, 3 vol % or more, 5 vol % or more, or 10 vol % or more, relative to the total amount of the fuel composition.

[0040] More specifically, the content of the oxygen-containing compound relative to the total amount of the fuel composition may be 0 vol % or more and less than 50 vol %, 0 to 40 vol %, 0 to 30 vol %, 0 to 25 vol %, 1 vol % or more and less than 50 vol %, 1 to 40 vol %, 1 to 30 vol %, 1 to 25 vol %, 3 vol % or more and less than 50 vol %, 3 to 40 vol %, 3 to 30 vol %, 3 to 25 vol %, 5 vol % or more and less than 50 vol %, 5 to 40 vol %, 5 to 30 vol %, 5 to 25 vol %, 10 vol % or more and less than 50 vol %, 10 to 40 vol %, 10 to 30 vol %, or 10 to 25 vol %.

[0041] The fuel composition of the present embodiment may further contain components other than the above. Examples of the other components include a cleaning dispersant, an antioxidant, a metal deactivator, a surface ignition inhibitor, an antifreeze agent, a combustion improver, an antistatic agent, a colorant, a rust inhibitor, a drainage agent, a fuel marker, an odorant, and a friction modifier. The total content of these other components may be, for example, 1 vol % or less, preferably 0.5 vol % or less, and more preferably 0.1 vol % or less, relative to the total amount of the fuel composition. Also, the total content of the other components may be, for example, 0.001 vol % or more, or 0.002 vol % or more, relative to the total amount of the fuel composition.

[0042] More specifically, the total content of the other components described above may be 0 to 1 vol %, 0 to 0.5 vol %, 0 to 0.1 vol %, 0.001 to 1 vol %, 0.001 to 0.5 vol %, 0.001 to 0.1 vol %, 0.002 to 1 vol %, 0.002 to 0.5 vol %, or 0.002 to 0.1 vol %.

[0043] As the cleaning dispersant, a commonly used cleaning dispersant may be used, and, for example, a compound known as a cleaning dispersant for gasoline such as succinimide, polyalkylamine, or polyetheramine may be used. Examples of the antioxidant include N,N'-diisopropyl-p-phenylenediamine, N,N'-diisobutyl-p-phenylenediamine, 2,6-di-t-butyl-4-methylphenol, and hindered phenols. Examples of the metal deactivator include an amine-carbonyl condensation compound such as N,N'-disalicylidene-1,2-diaminopropane. Examples of the surface ignition inhibitor include an organic phosphorus compound. Examples of the antifreeze agent include a polyhydric alcohol or an ether thereof. Examples of the combustion improver include an alkali metal salt or alkaline earth metal salt of organic acid, and a higher alcohol sulfate ester. Examples of the antistatic agent include an anionic surfactant, a cationic surfactant, and an amphoteric surfactant. Examples of the colorant include an azo dye. Examples of the rust inhibitor include an organic carboxylic acid and a derivative thereof, and an alkenyl succinic acid ester. Examples of the drainage agent include sorbitan esters. Examples of the fuel marker include kilyzanine and coumarin. Examples of the odorant include a natural essential oil and a synthetic fragrance. Examples of the friction modifier include a mixture of a higher carboxylic acid monoglyceride and a higher carboxylic acid amide compound.

[0044] A preferred embodiment of the present invention has been described above, though the present invention is not limited thereto.

EXAMPLES

[0045] The present invention will be described in more detail with reference to Examples as follows, though the present invention is not limited thereto.

Example 1

[0046] As the fuel composition, a fuel composition having a composition shown in the following Table 1 was prepared. The composition of the fuel composition is based on the values measured by the method described in JIS K 2536-2 "Liquid petroleum products-Testing method of components, Part 2: Determination of total components by gas chromatography". Using the prepared fuel composition, the lean limit was measured by the following method. The results are shown in Table 1.

[0047] <Measurement of Lean Limit>

[0048] With use of the following test engine, the lean limit was measured by changing the excess air ratio under conditions with a rotation speed of 2000 rpm, an indicated mean effective pressure of 800 kPa, and a minimum spark advance for best torque (MBT). The excess air ratio at a point where the fluctuation rate of the indicated mean effective pressure exceeds 3% was presumed as the lean limit. The excess air ratio is the air-fuel ratio of the air-fuel mixture during testing divided by the theoretical air-fuel ratio of the fuel composition, which is the reciprocal of equivalence ratio ϕ.

[0049] (Test Engine)

[0050] Engine: single cylinder

[0051] Displacement: 563 cc

[0052] Injection method: port injection

Examples 2 to 10, and Comparative Examples 1 to 3

[0053] The composition of the fuel composition was changed to the composition shown in Table 1, Table 2 or Table 3, and the lean limit was measured in the same manner as in Example 1. The results are shown in Table 1, Table 2 or Table 3. In Example 9, ethanol was used as the oxygen-containing compound, and in Example 10, 2-methylfuran was used as the oxygen-containing compound. Further, Comparative Example 1 is an example with use of high-octane gasoline, and the oxygen content in Comparative Example 1 indicates the content of the oxygen-containing compound contained in high-octane gasoline.

[0054] In the tables, "Saturated content" indicates the content (vol %) of saturated hydrocarbons, "Unsaturated content" indicates the content (vol %) of unsaturated hydrocarbons (excluding aromatic compounds), "Aromatic content" indicates the content (vol %) of aromatic compounds, "Oxygenates content" indicates the content (vol %) of oxygen-containing compounds, and "Total" indicates the total content (vol %) of saturated hydrocarbons, unsaturated hydrocarbons, aromatic compounds and oxygen-containing compounds.

[0055] Further, in the tables, "C4 to C6 hydrocarbon" indicates the content (vol %) of hydrocarbons having 4 to 6 carbon atoms in the fuel composition, "n-Paraffin" indicates the content (vol %) of normal paraffins having 4 to 6 carbon atoms relative to the total amount of hydrocarbons having 4 to 6 carbon atoms, "Isoparaffin" indicates the content of isoparaffins having 4 to 6 carbon atoms relative to the total amount of hydrocarbons having 4 to 6 carbon atoms, "Olefin" indicates the content (vol %) of olefins having 4 to 6 carbon atoms relative to the total amount of hydrocarbons having 4 to 6 carbon atoms, and "Subtotal" indicates the total content (vol %) of normal paraffins having 4 to 6 carbon atoms, isoparaffins having 4 to 6 carbon atoms, and olefins having 4 to 6 carbon atoms relative to the total amount of hydrocarbons having 4 to 6 carbon atoms.

TABLE 1

	Example 1	Example 2	Example 3	Example 4	Example 5
Saturated content	72.2	45.4	44.3	49.8	55.4
Unsaturated content	8.0	33.7	54.1	48.7	43.3
Aromatic content	20.1	21.0	1.9	1.8	1.5
Oxygenates content	—	—	—	—	—
C4 TO C6 HYDROCARBON	50.3	68.7	87.5	88.5	90.0
n-Paraffin	34.8	5.2	5.2	10.6	4.0
Isoparaffin	60.7	32.4	32.4	33.3	47.4
Olefin	2.7	56.7	56.7	50.5	44.1
Subtotal	98.2	94.3	94.3	94.3	95.6
Lean limit	2.17	2.20	2.23	2.25	2.30

TABLE 2

	Example 6	Example 7	Example 8	Example 9	Example 10
Saturated content	72.1	55.0	57.6	39.8	35.4
Unsaturated content	27.1	43.8	41.3	48.7	43.3
Aromatic content	1.0	1.6	1.5	1.7	1.5
Oxygenates content	—	—	—	10.0	20.0
C4 TO C6 HYDROCARBON	93.7	90.1	90.8	78.7	70.0
n-Paraffin	2.4	11.8	13.4	5.2	5.2
Isoparaffin	68.5	38.7	40.3	32.4	32.4
Olefin	26.5	44.6	41.7	56.7	56.7
Subtotal	97.4	95.1	95.4	94.3	94.3
Lean limit	2.32	2.35	2.40	2.26	2.38

TABLE 3

	Comparative Example 1	Comparative Example 2	Comparative Example 3
Saturated content	40.1	46.6	71.4
Unsaturated content	19.1	13.3	6.7
Aromatic content	37.8	40.0	21.3
Oxygenates content	2.9	—	—
C4 TO C6 HYDROCARBON	49.9	0.0	11.7
n-Paraffin	9.8	0.0	56.0
Isoparaffin	45.5	0.0	43.8
Olefin	33.5	0.0	0.2
Subtotal	88.8	0.0	100.0
Lean limit	1.99	2.01	1.99

1. A fuel composition for a lean burn engine comprising hydrocarbons having 4 to 6 carbon atoms as main component, with an aromatic content of 25 vol % or less.

2. The fuel composition for a lean burn engine according to claim **1**, wherein the content of olefins having 4 to 6 carbon atoms is 20 to 60 vol % relative to the total amount of hydrocarbons having 4 to 6 carbon atoms.

3. The fuel composition for a lean burn engine according to claim **1**, wherein the content of normal paraffins having 4 to 6 carbon atoms is 20 vol % or less relative to the total amount of hydrocarbons having 4 to 6 carbon atoms.

4. The fuel composition for a lean burn engine according to claim **1**, wherein the content of hydrocarbons having 4 to 6 carbon atoms is 85 vol % or more.

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