

Description

Title of Invention

METHOD, SYSTEM, AND APPARATUS

5

Cross Reference to Related Application

The present disclosure relates to subject matter contained in Japanese Patent Application No. 2024-32554, filed on March 4, 2024, and Japanese Patent Application No. 2024-124634, filed on July 31, 2024, the disclosures of which are
10 expressly incorporated herein by reference in their entirety.

Technical Field

[0001]

The present invention relates to a method, a system, and an apparatus.
15

Background Art

[0002]

Conventionally, an additive has been added to fuel oil in order to improve the combustibility of fuel oil such as heavy oil or to reduce harmful substances in
20 exhaust gas such as black smoke and an unburned content. A fuel oil tank is often open to the atmosphere, and it is possible to add an additive to the fuel oil by putting the additive into the tank.

[0003]

In addition, in recent years, there is a demand to use ammonia, methane,
25 methanol, or the like as a fuel in order to suppress emission of greenhouse gases.

Ammonia, methane, or the like has a low boiling point and is likely to evaporate, and methanol, ammonia, or the like is often stored in an enclosed tank due to their risk and toxicity. It is not easy to put an additive into the enclosed tank.

[0004]

5 In addition, in a case where a fuel having low ignitability is used as a main fuel, a fuel having high ignitability is supplied to a combustion chamber as a pilot fuel when initiating the combustion of the main fuel. When the pilot fuel ignites and combusts and a flame temperature in the combustion chamber increases, the main fuel easily combusts or the combustion of the main fuel is
10 easily controlled.

Summary of Invention

Technical Problem

[0005]

15 At least one object of the present invention is to provide a novel method for using an additive in a fuel.

Solution to Problem

[0006]

20 According to the invention, the above object is achieved by any of the following:

[1] A method comprising: combusting a pilot fuel and an additive in a combustion chamber; and combusting a main fuel in the combustion chamber using combustion heat of the pilot fuel;

25 [2] The method according to [1], further comprising: mixing the additive

with the pilot fuel; and supplying the pilot fuel mixed with the additive into the combustion chamber;

[3] The method according to [1], further comprising: supplying the additive into the combustion chamber; and supplying the pilot fuel into the
5 combustion chamber;

[4] The method according to [1], further comprising: mixing the main fuel and air in a premixing chamber; and supplying the additive into the premixing chamber;

[5] The method according to any one of [1] to [4], wherein the main fuel
10 is ammonia, natural gas, methane, methanol, ethanol, ethane, petroleum gas, and/or hydrogen gas, the pilot fuel is light oil, kerosene, heavy oil, and/or biofuel, and the additive is an organic metal salt, an inorganic metal salt, an amine, an ether, an ester, an alkyl nitrate, an alkyl nitrite, an amine nitrate, an alkylene nitrate, a peroxide, an azo compound, a diazo compound, ammonium nitrate,
15 and/or a composite thereof;

[6] The method according to any one of [1] to [3] and [5], further comprising: supplying the main fuel into the combustion chamber; and supplying air into the combustion chamber;

[7] The method according to any one of [1] to [5], further comprising:
20 mixing the main fuel and air in a premixing chamber; and supplying the mixed main fuel and air into the combustion chamber;

[8] A system comprising: a pilot fuel combustor that combusts a pilot fuel and an additive in a combustion chamber; and a main fuel combustor that combusts a main fuel in the combustion chamber using combustion heat of the
25 pilot fuel;

[9] An apparatus comprising a combustion chamber configured to combust a pilot fuel and an additive and to combust a main fuel using combustion heat of the pilot fuel;

[10] The apparatus according to [9], further comprising an additive
5 supplier that supplies the additive into the combustion chamber;

[11] The apparatus according to [9], further comprising: a premixing chamber configured to mix the main fuel and air; and an additive supplier that supplies the additive into the premixing chamber.

10 Advantageous Effects of Invention

[0007]

According to the present invention, it is possible to provide a novel method for using an additive in a fuel.

15 Brief Description of Drawings

[0008]

Figs. 1A and 1B are views for explaining an example of a mode in which a pilot fuel mixed with an additive is supplied into a combustion chamber according to an embodiment of the present invention.

20 Figs. 2A and 2B are views for explaining an example of a mode in which an additive and a pilot fuel are supplied into a combustion chamber according to an embodiment of the present invention.

Fig. 3 is a view for explaining an example of a mode in which a main fuel mixed with an additive and a pilot fuel are supplied into a combustion chamber
25 according to an embodiment of the present invention.

Description of Embodiments

[0009]

Hereinafter, embodiments of the invention will be described. However,
5 the invention is not limited to the following embodiments without departing from
the spirit and scope of the invention.

[0010]

The method of the present invention includes combusting a pilot fuel
and an additive in a combustion chamber, and combusting a main fuel in the
10 combustion chamber using combustion heat of the pilot fuel. The additive may
improve ignitability and/or combustibility. Here, the phrase “improving the
ignitability” may mean making a fuel easy to ignite. The phrase “making the fuel
easy to ignite” may be, for example, shortening the time it takes for the fuel to
ignite. In addition, here, the phrase “improving the combustibility” may mean
15 increasing a degree of combustion of the fuel. The phrase “increasing the
degree of combustion of the fuel” may be, for example, causing the fuel to burn
more vigorously. In addition, the additive may improve sustainability of
ignitability and/or combustibility. Here, the phrase “improving the sustainability
of the ignitability” may mean that the fuel easily maintains excellent ignitability.
20 The phrase “the fuel easily maintains the excellent ignitability” may mean
extending the time that the fuel remains in an easily ignitable state. In addition,
here, the phrase “improving the sustainability of the combustibility” may mean
that the fuel easily maintains excellent combustibility. The phrase “the fuel easily
maintains excellent combustibility” may mean extending the time during which
25 the fuel remains in a sufficiently combusted state.

[0011]

The fuel used as the main fuel is not particularly limited, and can be appropriately designed. The main fuel may be, for example, ammonia, natural gas, methane, methanol, ethanol, ethane, petroleum gas, hydrogen gas, or the like. The main fuel need not be heavy oil.

[0012]

The main fuel may be a fuel having a boiling point lower than that of heavy oil. For example, the boiling point of the main fuel at 1 atm may be 30°C or higher, 60°C or higher, or 150°C or higher. In addition, for example, the boiling point of the main fuel at 1 atm may be 290°C or lower, 270°C or lower, or 255°C or lower. Note that, in general properties of heavy oil, the boiling point is 300°C or higher.

[0013]

In addition, the main fuel may be a fuel having an ignition temperature (self-ignition temperature) higher than that of heavy oil. For example, the ignition temperature of the main fuel at 1 atm may be 350°C or higher or may be 400°C or higher. In addition, for example, the ignition temperature of the main fuel at 1 atm may be 660°C or lower or may be 550°C or lower. Note that, in general properties of heavy oil, the ignition temperature is about 250 to 300°C.

[0014]

The state of the main fuel at 1 atm and 23°C may be a liquid or gas.

[0015]

Note that the main fuel may be a fuel to be mainly combusted. The main fuel may be a fuel that is stored in a manner in which it is not easy to add an additive. In addition, the main fuel may be less likely to ignite as compared

with the pilot fuel, or need not be easy to control combustion after ignition.

[0016]

A fuel used as the pilot fuel is not particularly limited, and can be appropriately designed. The pilot fuel may be, for example, light oil, kerosene,
5 heavy oil, or the like. In addition, the pilot fuel may be, for example, biofuel (FAME: fatty acid methyl ester, HVO: hydrotreated vegetable oil, SVO: straight vegetable oil, or the like).

[0017]

The state of the pilot fuel at 1 atm and 23°C may be a liquid or gas.

10 [0018]

Note that the pilot fuel need not be a target to be mainly combusted. The pilot fuel may easily ignite as compared with the main fuel, or may be easily controlled for combustion after ignition. The amount of pilot fuel used is preferably smaller than the amount of main fuel used.

15 [0019]

A composition used as an additive is not particularly limited, and can be appropriately designed. The additive may be, for example, a combustion improver, an ignition improver, and/or a black smoke inhibitor. The function of the additive may be, for example, a function of improving the ignitability of the
20 fuel, a function of improving the combustibility of the fuel, a function of improving the sustainability of the ignitability of the fuel, a function of improving the sustainability of the combustibility of the fuel, a function of adjusting components of exhaust gas, a function of reducing the amount of harmful substances contained in the exhaust gas, and the like. One kind of additive may have one
25 function or two or more functions. Two or more kinds of additives may be mixed

and used as one additive. The function of the additive may be for the pilot fuel or the main fuel.

[0020]

In addition, the additive may be, for example, an organic metal salt, an
5 inorganic metal salt, an amine, an ether, an ester, an alkyl nitrate, an alkyl nitrite,
an amine nitrate, an alkylene nitrate, a peroxide, an azo compound, a diazo
compound, ammonium nitrate, and/or a composite thereof. Note that the above
examples indicate that the additive may have a functional group or the like
specific to the compound of the above system. In this case, a molecular weight
10 of the additive is not particularly limited. For example, the ether may be a
compound having an ether bond in a molecule.

[0021]

The state of the additive at 1 atm and 23°C may be a liquid or a solid
(for example, powder). The additive may be obtained by dispersing a
15 predetermined compound in a solvent. Examples of the compound contained in
the additive include a sulfonate compound of iron, manganese, barium, cerium,
calcium, magnesium, or the like, an octylic acid compound of iron, manganese,
barium, cerium, calcium, magnesium, or the like, an oleic acid compound of iron,
manganese, barium, cerium, calcium, magnesium, or the like, an oxide of iron,
20 manganese, barium, cerium, calcium, magnesium, or the like, a carbonate of iron,
manganese, barium, cerium, calcium, magnesium, or the like, a hydroxide of iron,
manganese, barium, cerium, or the like, dimethyl ether, diethyl ether, butyl nitrate,
isoamyl nitrate, amyl nitrate, heptyl nitrate, hexyl nitrate, 2-ethylhexyl nitrate, octyl
nitrate, isooctyl nitrate, decan-4-yl nitrate, decyl nitrate, dodecyl nitrate,
25 cyclopentyl nitrate, cyclohexyl nitrate, methylcyclohexyl nitrate,

isopropylcyclohexyl nitrate, propyl nitrite, butyl nitrite, t-butyl nitrite, amyl nitrite, isoamyl nitrite, hexyl nitrite, heptyl nitrite, octyl nitrite, nonyl nitrite, amine nitrate, 2,2-dinitropropane, alkylene nitrate, benzoyl peroxide, methyl ethyl ketone peroxide, di-t-butyl peroxide, t-butyl cumyl peroxide, dicumyl peroxide, 2,5-
5 dimethyl-2,5-di(t-butylperoxy)hexyne-3, 2,5-dimethyl-2,5-di(t-butylperoxy)hexane, 1,3-bis(t-butylperoxyisopropyl)benzene, 1,4-bis(t-butylperoxyisopropyl)benzene, di(2,4-dichlorobenzoyl)peroxide, 1,1-di(t-butylperoxy)cyclohexane, n-butyl-4,4'-di(t-butylperoxy)valerate, 1,1'-azobis(1-acetoxycyclohexane), 1,1'-azobis(1-methoxycyclohexane), 2,2'-azobis(2-
10 acetoxybutane), 2,2'-azobis(2-acetoxy-3-methylbutane), 2,2'-azobis(2-acetoxy-4-methylpentane), 2,2'-azobis(2-methoxy-4-methylpentane), 2,2'-azobis(2-propynoxy-4-methylpentane), azobisisobutyronitrile, azobenzene, diazodinitrophenol, diazoaminobenzene, methyl diazoacetate, ethyl diazoacetate, ammonium nitrate, ethylammonium nitrate, triethylammonium nitrate, and/or a
15 composite thereof. The solvent may be, for example, light oil, kerosene, biofuel, or the like.

[0022]

A viscosity of the additive is not particularly limited, and can be appropriately designed. In addition, the amount of additive used is not
20 particularly limited, and can be appropriately designed. Note that the amount of additive used may be defined as an amount with respect to the amount of pilot fuel used, or may be defined as an amount with respect to the amount of main fuel used.

[0023]

25 The combustion chamber may be a chamber provided with a space for

combusting a fuel. The combustion chamber may be provided in an internal combustion engine or an external combustion engine. In addition, the combustion chamber may be provided in a ship, a vehicle, a boiler in a factory, a generator in a factory, a generator in a power plant, or the like.

5 [0024]

It is preferable that the pilot fuel initiates combustion (that is, ignites) in the combustion chamber prior to the main fuel or substantially simultaneously with the main fuel. The main fuel can combust in the combustion chamber using heat generated when the pilot fuel combusts (hereinafter, also referred to as
10 combustion heat of the pilot fuel). The phrase “the main fuel combusts using the combustion heat of the pilot fuel” may include that the main fuel ignites using the combustion heat of the pilot fuel, that the main fuel continues to combust using the combustion heat of the pilot fuel after the main fuel ignites, and the like.

[0025]

15 Note that the pilot fuel may initiate combustion in the combustion chamber after the main fuel. In this case, after the main fuel ignites, the main fuel can continue combustion using combustion heat of the pilot fuel.

[0026]

It is preferable that the pilot fuel combusts together with an additive that
20 improves ignitability and combustibility. In addition, it is preferable that the additive also has a function of improving sustainability of ignitability and combustibility. The phrase “the pilot fuel combusts together with the additive” may be that the pilot fuel and the additive combust in the same space (combustion chamber). The pilot fuel and the additive may initiate combustion
25 at the same time, or either may initiate combustion first. Note that the pilot fuel

need not always combust together with the additive, and it is sufficient that there is a timing at which the pilot fuel combusts together with the additive.

[0027]

In addition, the pilot fuel may also be used in initiating combustion (that is, ignition) of the main fuel or may be used while the main fuel is combusting. For example, in a case where the combustion chamber is provided in a burner or the like, the supply of the pilot fuel may be continued not only when the combustion of the main fuel is initiated but also while the main fuel is combusting.

[0028]

A mode of supplying the main fuel, the pilot fuel, and the additive to the combustion chamber is not particularly limited, and can be appropriately designed. Hereinafter, an example of a mode of supplying the main fuel, the pilot fuel, and the additive to the combustion chamber will be described with reference to Figs. 1A to 3.

[0029]

Figs. 1A and 1B are views for explaining an example of a mode in which a pilot fuel mixed with an additive is supplied into a combustion chamber according to an embodiment of the present invention. In Figs. 1A and 1B, the additive is mixed with the pilot fuel in advance, and the pilot fuel mixed with the additive is supplied into the combustion chamber.

[0030]

Fig. 1A is a view for explaining an example of a mode in which the main fuel and air are separately supplied into the combustion chamber. A combustion chamber 1 illustrated in Fig. 1A includes a main fuel supply unit 2, a mixture supply unit 3 for a pilot fuel and an additive (hereinafter, also referred to as a

mixture supply unit 3), and an air supply unit 4.

[0031]

The main fuel supply unit 2 supplies a main fuel 21 into the combustion chamber 1. A method by which the main fuel supply unit 2 supplies the main
5 fuel 21 into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, the main fuel supply unit 2 may inject the main fuel 21 to supply the main fuel 21 into the combustion chamber 1. The main fuel supply unit 2 may include an injection valve. In addition, the main fuel supply unit 2 may be connected to a tank that stores the main fuel. The main
10 fuel supply unit 2 may send the main fuel from the tank to the combustion chamber 1 by a pump, a compressor, or the like. In this case, the state of the main fuel 21 may be a liquid or gas.

[0032]

The mixture supply unit 3 supplies a mixture 31 of a pilot fuel and an
15 additive (hereinafter, also referred to as a mixture 31) into the combustion chamber 1. A method by which the mixture supply unit 3 supplies the mixture 31 into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, the mixture supply unit 3 may inject the mixture 31 to supply the mixture into the combustion chamber 1. The mixture
20 supply unit 3 may include an injection valve. In addition, the mixture supply unit 3 may be connected to a tank that stores the mixture 31. The tank that stores the mixture 31 may be a tank containing the pilot fuel into which an additive is put. The mixture supply unit 3 may send the mixture 31 from the tank to the combustion chamber 1 by a pump or the like. In this case, the state of the
25 mixture 31 may be a liquid.

[0033]

The air supply unit 4 supplies air 41 into the combustion chamber 1. A method by which the air supply unit 4 supplies the air 41 into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, the air supply unit 4 may send the air 41 into the combustion chamber 1 by a blower or the like. The air supply unit 4 may include a valve.

[0034]

Although not illustrated, the combustion chamber 1 may include an exhaust port, an exhaust valve, an exhaust pipe, and the like for exhausting gas in the combustion chamber 1.

[0035]

In Fig. 1A, for example, the air 41 is supplied into the combustion chamber 1 by the air supply unit 4, the air 41 in the combustion chamber 1 is compressed by a piston or the like, and then the mixture 31 of the pilot fuel and the additive and the main fuel 21 are supplied into the combustion chamber 1, such that the pilot fuel and the additive are combusted, and the main fuel may be combusted using the combustion heat of the pilot fuel.

[0036]

A timing of supplying the mixture 31 of the pilot fuel and the additive and the main fuel 21 into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, the main fuel 21 may be supplied into the combustion chamber 1 after the mixture 31 is supplied into the combustion chamber 1 and combusts, or the mixture 31 and the main fuel 21 may be simultaneously supplied into the combustion chamber 1. In addition, the supply of the mixture 31 may be stopped when the main fuel 21 ignites, and the

supply of the mixture 31 may be continued even after the main fuel 21 ignites.

[0037]

Fig. 1B is a view for explaining an example of a mode in which the main fuel and air are mixed and supplied into the combustion chamber. A combustion chamber 1 illustrated in Fig. 1B includes a mixture supply unit 3 for a pilot fuel and an additive, a premixing chamber 5, and a gas supply unit 6.

[0038]

For the mixture supply unit 3, the description in Fig. 1A can be referred to within a necessary range.

10 [0039]

The premixing chamber 5 is a chamber provided with a space for premixing a main fuel 21 and air 41 before being supplied to the combustion chamber 1. The gas supply unit 6 supplies the main fuel 21 and the air 41 into the premixing chamber 5. A method by which the gas supply unit 6 supplies the main fuel 21 and the air 41 into the premixing chamber 5 is not particularly limited, and can be appropriately designed. For example, the gas supply unit 6 may send the main fuel from a tank to the premixing chamber 5 by a compressor or the like. In addition, for example, the gas supply unit 6 may send the air 41 into the premixing chamber 5 by a blower or the like. The gas supply unit 6 may include a valve. In this case, the state of the main fuel 21 is preferably a gas.

[0040]

A method for supplying a mixture 51 of a main fuel and air (hereinafter, also referred to as a mixture 51) from the premixing chamber 5 into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, a valve may be provided between the premixing

chamber 5 and the combustion chamber 1.

[0041]

Although not illustrated, the combustion chamber 1 may include an exhaust port, an exhaust valve, an exhaust pipe, and the like for exhausting gas
5 in the combustion chamber 1.

[0042]

In Fig. 1B, for example, the main fuel 21 and the air 41 are mixed in the premixing chamber 5, the mixture 51 of the main fuel and the air is supplied into the combustion chamber 1, the mixture 51 in the combustion chamber 1 is
10 compressed by a piston or the like, and then the mixture 31 of the pilot fuel and the additive is supplied into the combustion chamber 1, such that the pilot fuel and the additive are combusted, and the main fuel may be combusted using the combustion heat of the pilot fuel. Note that, when igniting the fuel, a spark may be generated by a spark plug or the like.

15 [0043]

A timing of supplying the mixture 31 of the pilot fuel and the additive and the mixture 51 of the main fuel and the air into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, the mixture 31 may be supplied into the combustion chamber 1 and then the mixture
20 51 may be supplied into the combustion chamber 1, or the mixture 31 and the mixture 51 may be simultaneously supplied into the combustion chamber 1. In addition, the supply of the mixture 31 may be stopped when the mixture 51 ignites, and the supply of the mixture 31 may be continued even after the mixture 51 ignites.

25 [0044]

As illustrated in Figs. 1A and 1B, when the additive is mixed with the pilot fuel in advance, it is not necessary to provide an additive supply unit configured to supply the additive to the combustion chamber 1, and it becomes easier to use the additive. In addition, in a case where the additive functions by combustion, the additive can initiate the function when the pilot fuel initiates combustion. Furthermore, since the pilot fuel is stored in the tank in an amount smaller than that of the main fuel, an addition ratio of the additive can be adjusted by further adding an additive or adding a pilot fuel containing no additive after mixing the additive with the pilot fuel. In addition, since the pilot fuel is contained in the tank in an amount smaller than that of the main fuel, it is also possible to use the pilot fuel containing other types of additives after the pilot fuel containing one additive is used up.

[0045]

Figs. 2A and 2B are views for explaining an example of a mode in which an additive and a pilot fuel are supplied into a combustion chamber according to an embodiment of the present invention. In Figs. 2A and 2B, the additive and the pilot fuel are separately supplied into the combustion chamber.

[0046]

Fig. 2A is a view for explaining an example of a mode in which the main fuel and air are separately supplied into the combustion chamber. A combustion chamber 1 illustrated in Fig. 2A includes a main fuel supply unit 2, an air supply unit 4, a pilot fuel supply unit 7, and an additive supply unit 8.

[0047]

For the main fuel supply unit 2 and the air supply unit 4, the description in Fig. 1A can be referred to within a necessary range.

[0048]

The pilot fuel supply unit 7 supplies a pilot fuel 71 into the combustion chamber 1. A method by which the pilot fuel supply unit 7 supplies the pilot fuel 71 into the combustion chamber 1 is not particularly limited, and can be
5 appropriately designed. For example, the pilot fuel supply unit 7 may inject the pilot fuel 71 to supply the pilot fuel into the combustion chamber 1. The pilot fuel supply unit 7 may include an injection valve. In addition, the pilot fuel supply unit 7 may be connected to a tank that stores the pilot fuel. The pilot fuel supply unit 7 may send the pilot fuel from the tank to the combustion chamber 1 by a pump,
10 a compressor, or the like. In this case, the state of the pilot fuel 71 may be a liquid or gas.

[0049]

The additive supply unit 8 supplies an additive 81 into the combustion chamber 1. A method by which the additive supply unit 8 supplies the additive
15 81 into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, the additive supply unit 8 may inject the additive 81 to supply the additive into the combustion chamber 1. The additive supply unit 8 may include an injection valve. In addition, the additive supply unit 8 may be connected to a tank that stores the additive. The additive supply unit
20 8 may send the additive from the tank to the combustion chamber 1 by a pump or the like. In this case, the state of the additive 81 is preferably a liquid.

[0050]

Although not illustrated, the combustion chamber 1 may include an exhaust port, an exhaust valve, an exhaust pipe, and the like for exhausting gas
25 in the combustion chamber 1.

[0051]

In Fig. 2A, for example, the air 41 is supplied into the combustion chamber 1 by the air supply unit 4, the air 41 in the combustion chamber 1 is compressed by a piston or the like, and then the pilot fuel 71, the additive 81, and the main fuel 21 are supplied into the combustion chamber 1, such that the pilot fuel and the additive are combusted, and the main fuel may be combusted using the combustion heat of the pilot fuel.

[0052]

A timing of supplying the pilot fuel 71, the additive 81, and the main fuel 21 into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, the main fuel 21 may be supplied into the combustion chamber 1 after the pilot fuel 71 and the additive 81 are supplied into the combustion chamber 1 and combust, or the pilot fuel 71, the additive 81, and the main fuel 21 may be simultaneously supplied into the combustion chamber 1. In addition, the supply of the pilot fuel 71 and the additive 81 may be stopped when the main fuel 21 ignites, and the supply of the pilot fuel 71 and the additive 81 may be continued even after the main fuel 21 ignites.

[0053]

In addition, a timing of supplying the pilot fuel 71 and the additive 81 into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, the pilot fuel 71 and the additive 81 may be simultaneously supplied into the combustion chamber 1, or the pilot fuel 71 and the additive 81 may be supplied into the combustion chamber 1 at different timings. The case of supplying the pilot fuel 71 and the additive 81 at different timings includes, for example, a case of supplying the additive 81 before

supplying the pilot fuel 71, a case of supplying the additive 81 twice—once before and once after supplying the pilot fuel 71, and the like.

[0054]

Fig. 2B is a view for explaining an example of a mode in which the main
5 fuel and air are mixed and supplied into the combustion chamber. A combustion chamber 1 illustrated in Fig. 2B includes a premixing chamber 5, a gas supply unit 6, a pilot fuel supply unit 7, and an additive supply unit 8.

[0055]

For the premixing chamber 5 and the gas supply unit 6, the description
10 in Fig. 1B can be referred to within a necessary range.

[0056]

For the pilot fuel supply unit 7 and the additive supply unit 8, the description in Fig. 2A can be referred to within a necessary range.

[0057]

15 Although not illustrated, the combustion chamber 1 may include an exhaust port, an exhaust valve, an exhaust pipe, and the like for exhausting gas in the combustion chamber 1.

[0058]

In Fig. 2B, for example, the main fuel 21 and the air 41 are mixed in the
20 premixing chamber 5, the mixture 51 of the main fuel and the air is supplied into the combustion chamber 1, the mixture 51 in the combustion chamber 1 is compressed by a piston or the like, and then the pilot fuel 71 and the additive 81 are supplied into the combustion chamber 1, such that the pilot fuel and the additive are combusted, and the main fuel may be combusted using the
25 combustion heat of the pilot fuel. Note that, when igniting the fuel, a spark may

be generated by a spark plug or the like.

[0059]

A timing of supplying the mixture 51 of the main fuel and the air, the pilot fuel 71, and the additive 81 into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, the mixture 51 may be supplied into the combustion chamber 1 after the pilot fuel 71 and the additive 81 are supplied into the combustion chamber 1, or the pilot fuel 71, the additive 81, and the mixture 51 may be simultaneously supplied into the combustion chamber 1. In addition, the supply of the pilot fuel 71 and the additive 81 may be stopped when the mixture 51 ignites, and the supply of the pilot fuel 71 and the additive 81 may be continued even after the mixture 51 ignites.

[0060]

In addition, a timing of supplying the pilot fuel 71 and the additive 81 into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, the pilot fuel 71 and the additive 81 may be simultaneously supplied into the combustion chamber 1, or the pilot fuel 71 and the additive 81 may be supplied into the combustion chamber 1 at different timings. In a case where the pilot fuel 71 and the additive 81 are supplied at different timings, examples include supplying the additive 81 before supplying the pilot fuel 71, supplying the additive 81 twice—once before and once after supplying the pilot fuel 71, and the like.

[0061]

As illustrated in Figs. 2A and 2B, when the additive and the pilot fuel are separately supplied into the combustion chamber, it is possible to arbitrarily adjust the amount of additive used with respect to the amount of pilot fuel used. In

addition, in a case where the additive functions by combustion, a timing at which the additive starts to function can be adjusted by adjusting the timing of supplying the additive and the pilot fuel to the combustion chamber. Furthermore, it is easy to change the type of additive to be used.

5 [0062]

Fig. 3 is a view for explaining an example of a mode in which a main fuel mixed with an additive and a pilot fuel are supplied into a combustion chamber according to an embodiment of the present invention. In Fig. 3, the additive is supplied into a premixing chamber and then supplied into the combustion
10 chamber.

[0063]

A combustion chamber 1 illustrated in Fig. 3 includes a premixing chamber 5, a gas supply unit 6, a pilot fuel supply unit 7, and an additive supply unit 8.

15 [0064]

For the premixing chamber 5 and the gas supply unit 6, the description in Fig. 1B can be referred to within a necessary range.

[0065]

For the pilot fuel supply unit 7, the description in Fig. 2A can be referred
20 to within a necessary range.

[0066]

The additive supply unit 8 supplies an additive 81 into the premixing chamber 5. A method by which the additive supply unit 8 supplies the additive 81 into the premixing chamber 5 is not particularly limited, and can be
25 appropriately designed. For example, the additive supply unit 8 may inject the

additive 81 to supply the additive into the premixing chamber 5. The additive supply unit 8 may include an injection valve. In addition, the additive supply unit 8 may be connected to a tank that stores the additive. The additive supply unit 8 may send the additive from the tank to the premixing chamber 5 by a pump or the like. In this case, the state of the additive 81 is preferably a liquid.

[0067]

In the premixing chamber 5, the additive 81 is mixed with a main fuel 21 and air 41. Therefore, a mixture 52 of the main fuel, the air, and the additive (hereinafter, also referred to as a mixture 52) is supplied from the premixing chamber 5 into the combustion chamber 1.

[0068]

Although not illustrated, the combustion chamber 1 may include an exhaust port, an exhaust valve, an exhaust pipe, and the like for exhausting gas in the combustion chamber 1.

[0069]

In Fig. 3, for example, the main fuel 21, the air 41, and the additive 81 are mixed in the premixing chamber 5, the mixture 52 of the main fuel, the air, and the additive is supplied into the combustion chamber 1, the mixture 52 in the combustion chamber 1 is compressed by a piston or the like, and then a pilot fuel 71 is supplied into the combustion chamber 1, such that the pilot fuel and the additive are combusted, and the main fuel may be combusted using the combustion heat of the pilot fuel. Note that, when igniting the fuel, a spark may be generated by a spark plug or the like.

[0070]

A timing of supplying the main fuel 21, the air 41, and the additive 81

into the premixing chamber 5 is not particularly limited, and can be appropriately designed. For example, the main fuel 21 and the air 41 may be supplied into the premixing chamber 5 and mixed, and then the additive 81 may be supplied, the main fuel 21, the air 41, and the additive 81 may be simultaneously supplied
5 into the premixing chamber 5 and mixed, or the main fuel 21 and the air 41 may be supplied into the premixing chamber 5 and mixed after the additive 81 is supplied into the premixing chamber 5.

[0071]

A timing of supplying the mixture 52 of the main fuel, the air, and the
10 additive, and the pilot fuel 71 into the combustion chamber 1 is not particularly limited, and can be appropriately designed. For example, the mixture 52 may be supplied into the combustion chamber 1 after the pilot fuel 71 is supplied into the combustion chamber 1, or the pilot fuel 71 and the mixture 52 may be simultaneously supplied into the combustion chamber 1. In addition, the supply
15 of the pilot fuel 71 may be stopped when the mixture 52 ignites, and the supply of the pilot fuel 71 may be continued even after the mixture 52 ignites.

[0072]

As illustrated in Fig. 3, in a case where the additive is supplied into the premixing chamber, it becomes easier to mix uniformly the main fuel and the
20 additive. In addition, since the additive and the pilot fuel are separately supplied into the combustion chamber, it is possible to arbitrarily adjust the amount of additive used with respect to the amount of pilot fuel used. Furthermore, in a case where the additive functions by combustion, a timing at which the additive starts to function can be adjusted by adjusting the timing of supplying the mixture
25 of the main fuel, the air, and the additive, and the pilot fuel to the combustion

chamber. In addition, it is easy to change the type of additive to be used.

[0073]

The timing and amount of the main fuel, the pilot fuel, the air, and/or the additive supplied into the combustion chamber may be controlled by a control
5 unit. In addition, the control unit may control processing related to fuel combustion in the combustion chamber, for example, processing related to gas compression in the combustion chamber, electric spark generation, exhaust from the combustion chamber, and the like.

[0074]

10 The present invention may be a system including a pilot fuel combustor that combusts a pilot fuel and an additive in a combustion chamber, and a main fuel combustor that combusts a main fuel in the combustion chamber using combustion heat of the pilot fuel.

[0075]

15 In addition, the present invention may be an apparatus including a combustion chamber configured to combust a pilot fuel and an additive and to combust a main fuel using combustion heat of the pilot fuel. The apparatus may be, for example, an engine, a boiler, or the like.

[0076]

20 Furthermore, the apparatus may include an additive supplier that supplies the additive into the combustion chamber.

[0077]

The apparatus may also include a premixing chamber configured to mix the main fuel and air, and an additive supplier that supplies the additive into the
25 premixing chamber.

[0078]

Accordingly, a novel method for using an additive in a fuel may be provided by a method including combusting a pilot fuel and an additive in a combustion chamber, and combusting a main fuel in the combustion chamber
5 using combustion heat of the pilot fuel.

[0079]

According to the method of the present invention, it is possible to use the additive when combusting the main fuel even when the main fuel is not stored in a state of being mixed with the additive. Therefore, an additive can also be
10 used, for example, in a case where a boiling point of the main fuel is low, in a case where an ignition temperature of the main fuel is high, in a case where ignitability of the main fuel is low, in a case where combustibility of the main fuel is low, in a case where it is not easy to uniformly mix an additive into the main fuel, in a case where the main fuel is stored in an enclosed tank because it has
15 hazardous, toxic, and/or environmentally hazardous properties, and the like.

[0080]

By improving the ignitability and the combustibility of the pilot fuel by the additive, there is a possibility that the ignitability and/or the combustibility of the main fuel can be improved. It is expected that fuel efficiency is improved by
20 improving the ignitability and/or combustibility of the main fuel. In addition, the main fuel can be combusted at an appropriate timing. In addition, there is a possibility that the ignitability and/or combustibility of the main fuel can be maintained in a preferred state by improving the sustainability of the ignitability and/or the combustibility of the pilot fuel by the additive. By maintaining the
25 ignitability and/or the combustibility of the main fuel in a preferred state, it is

possible to lengthen the time during which the main fuel combusts and increase the integration of the amount of heat obtained as a result.

[0081]

In addition, the additive is used, such that components contained in the exhaust gas after the main fuel combusts can be reformed, and the load on the environment can be reduced. Furthermore, the additive is used, such that air pollutants contained in the exhaust gas after the main fuel combusts can be reduced, and the load on the environment can be reduced.

10 Reference Signs List

[0082]

1	Combustion chamber
2	Main fuel supply unit
3	Mixture supply unit for pilot fuel and additive
15 4	Air supply unit
5	Premixing chamber
6	Gas supply unit
7	Pilot fuel supply unit
8	Additive supply unit
20 21	Main fuel
31	Mixture of pilot fuel and additive
41	Air
51	Mixture of main fuel and air
52	Mixture of main fuel, air, and additive
25 71	Pilot fuel

81 Additive

Claims

1. A method comprising:
5 combusting a pilot fuel and an additive in a combustion chamber; and
 combusting a main fuel in the combustion chamber using combustion
heat of the pilot fuel.

10 2. The method according to claim 1, further comprising:
 mixing the additive with the pilot fuel; and
 supplying the pilot fuel mixed with the additive into the combustion
chamber.

15 3. The method according to claim 1, further comprising:
 supplying the additive into the combustion chamber; and
 supplying the pilot fuel into the combustion chamber.

20 4. The method according to claim 1, further comprising:
 mixing the main fuel and air in a premixing chamber; and
 supplying the additive into the premixing chamber.

25

5. The method according to any one of claims 1 to 4, wherein the main fuel is ammonia, natural gas, methane, methanol, ethanol, ethane, petroleum gas, and/or hydrogen gas,

the pilot fuel is light oil, kerosene, heavy oil, and/or biofuel, and

5 the additive is an organic metal salt, an inorganic metal salt, an amine, an ether, an ester, an alkyl nitrate, an alkyl nitrite, an amine nitrate, an alkylene nitrate, a peroxide, an azo compound, a diazo compound, ammonium nitrate, and/or a composite thereof.

10

6. The method according to any one of claims 1 to 3 and 5, further comprising:

supplying the main fuel into the combustion chamber; and

supplying air into the combustion chamber.

15

7. The method according to any one of claims 1 to 5, further comprising:

mixing the main fuel and air in a premixing chamber; and

supplying the mixed main fuel and air into the combustion chamber.

20

8. A system comprising:

a pilot fuel combustor that combusts a pilot fuel and an additive in a combustion chamber; and

25 a main fuel combustor that combusts a main fuel in the combustion

chamber using combustion heat of the pilot fuel.

9. An apparatus comprising a combustion chamber configured to combust
5 a pilot fuel and an additive and to combust a main fuel using combustion heat of
the pilot fuel.

10. The apparatus according to claim 9, further comprising an additive
10 supplier that supplies the additive into the combustion chamber.

11. The apparatus according to claim 9, further comprising:
a premixing chamber configured to mix the main fuel and air; and
15 an additive supplier that supplies the additive into the premixing
chamber.