

HYDROGEN PRODUCING FUEL SYSTEM AND ENGINE SYSTEM

Technical Field

[0001] Embodiments relate generally to a fuel system for an engine and an engine system comprising the same, and more particularly to a dual fuel system for an engine.

Background

[0002] Fossil fuels, such as oil, natural gas and coal, constitute the primary source of energy in the world. However, fossil fuels are valuable non-renewable resources, viable reserves of which will be depleted fast at the current rate of consumption.

[0003] On the other hand, vehicle use of fossil fuels gives rise to pollution. For example, car exhaust gas contains nitrogen oxides, which under the action of sunlight react with the hydrocarbons to form photochemical smog and ozone. This can precipitate or exacerbate asthma in sensitive people. Car exhaust gas can also be toxic due to its carbon monoxide content, which may be dangerous to passengers when the carbon monoxide leaks into the inside of cars. Car exhaust gas also contributes to air pollution, which has been linked with various respiratory illnesses, heart disease, and lung cancer.

Summary

[0004] Various embodiments provide a fuel system for a combustion engine. The fuel system may include a fuel supply configured to supply an alcohol-water mixture; and a converter configured to convert the alcohol-water mixture received from the fuel supply

to an activated alcohol-water mixture, and supply the activated alcohol-water mixture to the combustion engine.

Brief Description of the Drawings

[0005] In the drawings, like reference characters generally refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments are described with reference to the following drawings, in which:

Fig. 1 shows a block diagram of a fuel system according to various embodiments.

Fig. 2 shows a block diagram of an engine system according to various embodiments.

Fig. 3 shows a schematic view of an engine system according to various embodiments.

Fig. 4 shows a schematic view of a gas fuel supply according to various embodiments.

Fig. 5 shows a schematic view of a fuel supply and a converter according to various embodiments.

Fig. 6 shows a schematic view of a combustion engine according to various embodiments.

Fig. 7 illustrates a cross-sectional view of a converter according to various embodiments.

Fig. 8 illustrates an isometric view of the converter of Fig. 7 according to various embodiments.

Fig. 9 illustrates an exploded view of the converter of Fig. 10 according to various embodiments.

Fig. 10 illustrates a schematic view of an inner tube of the converter according to various embodiments.

Description

[0006] Various embodiments provide a fuel system and an engine system comprising the fuel system.

[0007] Fig. 1 shows a block diagram of a fuel system 100 for a combustion engine according to various embodiments.

[0008] The fuel system 100 may include a fuel supply 104 configured to supply an alcohol-water mixture. The fuel system may include a converter 106 configured to convert the alcohol-water mixture received from the fuel supply 104 to an activated alcohol-water mixture, and supply the activated alcohol-water mixture to the combustion engine.

[0009] In various embodiments, the alcohol-water mixture may include ethanol or methanol. In various embodiments, the alcohol-water mixture may include an ethanol-water mixture, or may include a methanol-water mixture. By way of example, the ethanol-water mixture may include a mixture of 50-60% ethanol by weight and 40-50% water by weight. The methanol-water mixture may include a mixture of 60-70% methanol by weight and 30-40% water by weight.

[0010] In various embodiments, the fuel supply 104 includes a fuel tank configured to store the alcohol-water mixture.

[0011] According to various embodiments, the fuel system 100 may further include a gas fuel supply (not shown in Fig. 1) configured to supply a gas fuel to the combustion engine. According to various embodiments, the gas fuel may include hydrogen gas. In various embodiments, the gas fuel may be a hydrogen-rich gas. In various embodiments, the gas fuel may include at least one of hydrogen gas, carbon monoxide (CO), carbon dioxide (CO₂) or methane (CH₄).

[0012] In various embodiments, the activated alcohol-water mixture is converted into a hydrogen rich gas in the combustion engine. In various embodiments, as a result of the conversion carried out in the combustion engine, the hydrogen rich gas produced thereby may include hydrogen gas and one or more of other gases, such as carbon monoxide (CO), carbon dioxide (CO₂) and methane (CH₄). In various embodiments, the gas fuel supplied from the gas fuel supply may be same or have same composition as the hydrogen rich gas produced in the combustion engine.

[0013] In various embodiments, atom links of the activated alcohol-water mixture are weaker than atom links of the alcohol-water mixture received by the converter. The activated alcohol-water mixture may refer to the alcohol-water mixture whose physical characteristic has been changed, e.g. by the converter 106, so as to have an active property. The active property may be represented by weaker atom links of alcohol and water in the activated alcohol-water mixture which are easier to be broken and easier to produce hydrogen thereby.

[0014] According to various embodiments, the converter 106 is a catalytic converter. The catalytic converter may be configured to convert the alcohol-water mixture to the activated alcohol-water mixture using a catalyst. The catalyst may be a hydrogen-

generating catalyst. The catalyst may be a high temperature zinc chromium based catalyst, or may include precious metal, such as Palladium or platinum, or may be other types of catalyst, for example, as used in CN1034248A. In various embodiments, the catalytic converter may be configured to convert the alcohol-water mixture to the activated alcohol-water mixture using the catalyst under a predetermined range of working temperature. Exemplary ranges of working temperature may be 55°C - 95°C, 65°C - 85°C, 70°C - 80°C, etc.

[0015] In various embodiments, the converter 106 is configured to change the physical characteristic of the alcohol-water mixture to obtain the activated alcohol-water mixture, such that atom links of alcohol and water in the activated alcohol-water mixture are weaker than atom links of alcohol and water in the alcohol-water mixture. By way of example, molecular formula of water is H-O-H, wherein two hydrogen atoms link to one oxygen atom. In order to produce hydrogen rich gas, the atom links of alcohol and water in the alcohol-water mixture should be broken so that the atoms will link with different element to produce hydrogen gas. As the atom link of water is very strong, it can only be broken under the electrolyzation, or high temperature and high pressure. In the converter 106 of various embodiments, when the alcohol-water mixture flows through the converter, the atom links of alcohol and water become weak, e.g. by using the catalyst in the converter under a predetermined range of working temperature and under a magnetic field, to form the activated alcohol-water mixture which is active and has weak atom links easier to be broken. In various embodiments, the converter 106 may not require high temperature and/or high pressure in order to generate the activated alcohol-water mixture, for example, due to the presence of the catalyst and the magnetic field.

Exemplary ranges of working temperature of the converter 106 may be 55°C - 95°C, 65°C - 85°C, 70°C - 80°C, etc. In various embodiments, the activated alcohol-water mixture from the converter 106 may be supplied to the combustion engine, so that the activated alcohol-water mixture with weak atom links may be easily converted into the hydrogen rich gas in the combustion engine.

[0016] In various embodiments, the converter 106 may include an inner tube, wherein the inner tube includes a plurality of inner tube holes for receiving catalyst on the inner wall of the inner tube holes. The inner tube holes may extend longitudinally along the inner tube. The alcohol-water mixture may contact with the catalyst on the inner wall of the inner tube holes when flowing through the inner tube holes.

[0017] In various embodiments, the converter 106 may be configured to use cooling water of the combustion engine to heat the inner tube. In various embodiments, the converter 106 may be configured to receive heat from the cooling water of the combustion engine, to heat the inner tube of the converter to a temperature between 55°C and 95°C. The temperature of cooling water of the combustion engine may be sufficiently high, for example, higher than 90°C, so that the converter 106 receives such heat for the catalyst to function.

[0018] In various embodiments, the converter may be configured to receive heat transferred from exhaust of the combustion engine. The converter 106 may be configured to start activate the alcohol-water mixture when heated to a predetermined temperature, for example, when heated to a temperature above 55°C.

[0019] In various embodiments, the converter 106 may include a layer of electromagnetic coils, and the converter 106 may be configured to convert the alcohol-

water mixture to the activated alcohol-water mixture under a magnetic field produced by the electromagnetic coils. Accordingly, electromagnetic effect of the electromagnetic coils may be utilized by the converter 106 to facilitate the activation of the alcohol-water mixture.

[0020] In various embodiments, the layer electromagnetic coils may surround the inner tube of the converter 106. In various embodiments, the electromagnetic coils may be connected to an engine controller. The electromagnetic coils may be charged by the engine controller. By way of example, the electromagnetic coils may receive a current, e.g., a DC electricity (direct current), from the engine controller, so as to produce a magnetic field under the control of the engine controller. For example, a small current may be supplied to the electromagnetic coils to produce a small magnetic field, which may be utilized to activate the alcohol-water mixture more effectively.

[0021] In various embodiments, the converter 106 may be configured to convert the alcohol-water mixture to the activated alcohol-water mixture using a catalyst under a predetermined range of working temperature and under a magnetic field provided to or in the converter 106. The magnetic field may be produced in the converter 106, e.g. by charging electromagnetic coils provided in the converter 106, or may be provided to the converter 106 from an external source. According to various embodiments, electromagnetic effect may be utilized to facilitate the conversion of the alcohol-water mixture to the activated alcohol-water mixture in a more effective manner.

[0022] In various embodiments, the converter 106 may include an outer case enclosing the converter. The outer case may be connected with a cooling water pipe of the combustion engine. The outer case may include a first part and a second part, wherein

the first part and the second part are snapped together by fastening a fixing lug of the first part with a fixing lug of the second part. The fixing lugs of the first and second part may be rubber rings and may be fastened together using bolts.

[0023] In various embodiments, the converter 106 may be configured to connect to at least one fuel spray nozzle of the combustion engine, so as to supply the activated alcohol-water mixture to the combustion engine via the at least one fuel spray nozzle. The converter 106 may be configured to spray the activated alcohol-water mixture into the combustion engine (e.g. into a cylinder or combustion chamber of the combustion engine) through the fuel spray nozzle. The at least one fuel spray nozzle may be controlled by the engine controller, e.g. with respect to the open or close state of the fuel spray nozzle, and/or the time duration of spraying the activated alcohol-water mixture into the combustion engine.

[0024] In various embodiments, the converter 106 may include a converter temperature sensor. The converter temperature sensor may be configured to detect the temperature in the converter. The at least one fuel spray nozzle may be controlled by an engine controller based on signals from the converter temperature sensor, so as to control the supply of the activated alcohol-water mixture to the combustion engine. By way of example, during a cold start-up stage of the combustion engine, the cooling water of the combustion engine may be cold at a low temperature and accordingly the converter 106 is not heated to a predetermined working temperature for conversion of the alcohol-water mixture to the activated alcohol-water mixture. The converter temperature sensor may detect that the temperature in the converter 106 is not a predetermined working

temperature, and accordingly the at least one fuel spray nozzle may be controlled to be closed.

[0025] According to various embodiments, the gas fuel supply may include a gas fuel tank configured to store the gas fuel, a gas injector track configured to receive the gas fuel from the gas fuel tank via a pipeline, and at least one valve disposed along the pipeline. The at least one valve may be controlled by an engine controller so as to control the supply of the gas fuel from the gas fuel tank to the gas injector track.

[0026] The gas injector track may be configured to supply the gas fuel to the combustion engine via at least one gas nozzle mounted on the gas injector track. The gas nozzle may be configured to be connected with an intake manifold of the combustion engine. The gas injector track may include a pressure and temperature sensor, wherein the at least one valve of the first fuel supply is controlled by the engine controller based on signals from the pressure and temperature sensor.

[0027] In various embodiments, the combustion engine may receive the activated alcohol-water mixture from the converter 106, and may additionally receive the gas fuel from the gas fuel supply, under the control of the engine controller. Hydrogen is the lightest element, and accordingly the density is the smallest. As the volume of the cylinder of the combustion engine is limited, when the hydrogen gas is supplied as the gas fuel, the amount of hydrogen gas which can be push into the cylinder is small due to small density of the hydrogen gas. Accordingly, the power of the combustion engine using the hydrogen gas may not be as strong as that using liquid fuel, e.g. gasoline. According to various embodiments, the fuel system supplies the activated alcohol-water mixture to the combustion engine, wherein the activated alcohol-water mixture in liquid

may carry more energy than the hydrogen gas fuel. The activated alcohol-water mixture is sprayed into the cylinder of the combustion engine, and is changed to the hydrogen rich gas inside the cylinder, e.g. under high temperature and pressure when air valve of the cylinder is closed. Accordingly, the energy or power of the combustion engine is higher compared to the combustion engine using hydrogen gas fuel only.

[0028] In various embodiments, the fuel system 100 may be controlled by an engine controller such that only the gas fuel is supplied to the combustion engine during a cold start-up phase of the combustion engine. This may ensure that the combustion engine can use the gas fuel when the working condition (e.g. temperature) in the combustion engine is not ready for conversion of the activated alcohol-water mixture. The engine controller described in this context may be a controller provided in the fuel system, or may be a controller provided for the combustion engine.

[0029] The fuel system 100 according to various embodiments may be used for an engine of automobiles, motorcycles, locomotives, ships, aircrafts, etc. The fuel system 100 according to various embodiments may also be used for an electric generator, wherein the electric generator may receive mechanical energy from a combustion engine using the fuel system and may generate power to run electrical devices.

[0030] Fig. 2 shows a block diagram of an engine system 200 according to various embodiments.

[0031] The engine system 200 may include the fuel system 100 described in various embodiments above, and may also include the gas fuel supply 102 described above. The engine system 200 may further include a combustion engine 112 and an engine controller

114 configured to control the supply of the alcohol & water fuel to the combustion engine 112.

[0032] Various embodiments described above with respect to the fuel system 100 of Fig. 1 are analogously valid for the engine system 200. Various embodiments of the combustion engine and the engine controller described above are also valid for the combustion engine 112 and the engine controller 114.

[0033] In various embodiments, the combustion engine 112 is an internal combustion engine. Examples of the combustion engine may include a gasoline engine, a diesel engine, etc.

[0034] In various embodiments, the combustion engine 112 may include at least one combustion chamber (also referred to as cylinder) and a spark plug for each combustion chamber. The engine controller 114 is configured to control the spark plug.

[0035] Various embodiments of the fuel system 100 and the engine system 200 will be described in more detail below with reference to the figures.

[0036] Fig. 3 shows a schematic view of an engine system 60 according to various embodiments.

[0037] The engine system 60 includes a gas fuel supply 63, a fuel supply 61, a converter 9, a combustion engine 1 and an Engine Control Unit (ECU) 16. The combustion engine 1 is connected to the gas fuel supply 63, and is connected to the fuel supply 61 through the converter 9. The ECU 16, also referred as the engine controller above, is electrically connected to the fuel supply 61, the gas fuel supply 63, the converter 9 and the combustion engine 1.

[0038] Fig. 4 shows an enlarged view of the gas fuel supply 63 according to various embodiments. The gas fuel supply 63 may include a gas fuel tank 3 (also referred to as a gas tank or a gas cylinder), a gas injector track 10 (also referred to as a gas rail or a gas air track), and a pipeline 24 (also referred to as a fuel conduit) connecting the gas fuel tank 3 and the gas injector track 10. The gas fuel supply 63 is configured to store the gas fuel (e.g., hydrogen-rich gas) and deliver the gas fuel to the combustion engine 1.

[0039] The gas tank 3 may include a cylindrical steel gas container that is capable of withstanding high pressure. The gas tank 3 may be configured to receive and store the gas fuel, e.g., compressed hydrogen-rich gas, which may be produced in a process similar to that carried out by the converter 9 and the combustion engine 1 to produce hydrogen rich gas from the alcohol-water mixture as described above. The externally produced hydrogen-rich gas may be compressed by an external pump into the gas tank 3, which can withstand a pressure up to a predetermined pressure level.

[0040] The pipeline 24 is connected to the gas tank 3 at one end, and is connected to the gas injector track 10 at another end. The pipeline 24 may include one or more valves disposed thereon. For example, a solenoid valve 12, a first relief valve 13, and a second relief valve 14 are disposed along the pipeline 24 separating the pipeline 24 into a plurality of fuel lines. The solenoid valve 12 may be electrically connected to the ECU 16, such that the ECU may control the supply of the gas fuel from the gas tank 3.

[0041] In illustrative embodiments, the solenoid valve 12 may be used to control the gas flow in the pipeline 24. Upon activation by the ECU 16, the solenoid valve 12 may operate in two states, an open state and a closed state.

[0042] In the open state, the valve 12 is opened, allowing a passage-way for the gas fuel to flow from the gas tank 3 to the pipeline 24. In the closed state, the valve 12 is closed, blocking the gas fuel flow from the gas tank 3 to the pipeline 24.

[0043] The first relief valve 13 may be configured to control the pressure in the part 21, 22 of the pipeline 24 between the gas tank 3 and the first relief valve 13, for example, to limit the pressure up to 20mpa. By way of example, the relief valve 13 may operate in an open state and a closed state. In the open state, the relief valve 13 is opened if the gas pressure in the part 22 of the pipeline 24 is more than a predetermined pressure level (e.g. 20mpa). The outlet of the valve 13 allows a portion of the gas to be discharged into the air. As the gas is vented, the pressure in the part 22 of the pipeline 24 drops. The valve 13 closes, once the pressure reaches below the predetermined pressure level (e.g. 20mpa). The valve 13 then operates in the closed state.

[0044] Similarly, the second relief valve 14 may be configured to control the pressure in the part 23 of the pipeline 24 from the first valve 13 to the second relief valve 14, for example, to limit the pressure up to 10mpa. In an open state, the relief valve 14 opens if the gas pressure in the part 23 of the pipeline 24 is more than a predetermined pressure level (e.g. 10mpa). The outlet of the valve 14 allows a portion of the gas to be discharged into the air. As the gas is vented, the pressure in the part 23 of the pipeline 24 drops. The valve 14 closes, once the pressure reaches a pressure below the predetermined pressure level (e.g. 10mpa).

[0045] The gas injection track 10 is provided to deliver the gas fuel from the gas tank 3 to the combustion engine 1. The gas injection track 10 may include an elongated body and one or more gas nozzles. In the examples shown in Fig. 3 and Fig. 4, four gas nozzles

11 are provided on the gas injection track 10. The elongated body of first gas injection track 10 has two end, one end of which has an opening connected to the pipeline 24 while another end which is sealed. Each gas nozzle 11 may be connected with the intake manifold runners 6 of the combustion engine unit 1, and may be configured to spray the gas fuel into the manifold runners 6 of the combustion engine 1. The gas nozzles 11 may be electrically connected to the ECU 16.

[0046] The gas injection track 10 also includes a gas pressure and temperature sensor 15, which is electrically connected to the ECU 16. Based on the signals from the gas pressure and temperature sensor 15 indicating the pressure and/or the temperature at the gas injection track 10, the ECU 16 may control the opening or closing of the solenoid valve 12, the first relief valve 13, and the second relief valve 14.

[0047] Fig. 5 shows an enlarged view of the fuel supply 61 and the converter 9 according to various embodiments, which may be an example of a fuel system 100 described with reference to Fig. 1 above.

[0048] The fuel supply 61 includes a fuel tank 2 configured to receive and store an alcohol-water mixture. The fuel tank 2 includes a container, which has an inlet and an outlet. The inlet is attached to a removable cover 25, so that when the cover 25 is removed, an alcohol-water mixture may be provided from an external source to refuel the fuel tank 2. The outlet of the alcohol tank 2 is connected to the converter 9 for supplying the alcohol-water mixture to the converter 9.

[0049] In various embodiments, a fuel filter 17 may be provided between the fuel tank 2 and the converter 9 to filter the alcohol-water mixture before it is supplied to the converter. The fuel filter 17 may be configured to remove dirt particles and impurities

from the alcohol-water mixture, so as to prevent them from depositing on the inner walls of the inner tube holes of the converter 9 and potentially affecting the efficiency of the chemical reaction process happening in the inner tube holes. The fuel filter 17 may be connected to the outlet of the fuel tank 2 at one end, and may be connected to the converter 9 through a fuel pipe 26 at the other end.

[0050] In various embodiments, the fuel tank 2 may include a fuel level sensor 8 configured to sense and/or monitor the level of alcohol-water mixture within the fuel tank 2. The fuel level sensor 8 may be electrically connected to the ECU 16 and may be controlled by the ECU 16. In various embodiments, when the level of alcohol-water mixture is lower than a predetermined level, the fuel level sensor 8 may send a detection signal to the ECU 16. The ECU 16 may send a control signal to the fuel tank 2 so that the fuel tank 2 may be refueled through the inlet. In various embodiments, when it is determined from the fuel level sensor 8 that the level of alcohol-water mixture is higher than a predetermined level, the ECU 16 may send a control signal to the fuel tank 2 so that the refueling of the fuel tank 2 may be stopped.

[0051] In various embodiments, the converter 9 may be a catalytic converter, or may be any other types of converter which is able to convert the alcohol-water mixture into the activated alcohol-water mixture as described above. In various embodiments, the converter 9 may be configured to convert the alcohol-water mixture to the activated alcohol-water mixture using a catalyst under a predetermined range of working temperature. Exemplary ranges of working temperature may be 55°C - 95°C, 65°C - 85°C, 70°C - 80°C, etc. The catalyst may be a hydrogen-generating catalyst. The catalyst may

be a high temperature zinc chromium based catalyst, or may include precious metal, such as Palladium or platinum.

[0052] The converter 9 may include a main body having an inlet and an outlet. The main body may be a metal cylindrical body, for example. The inlet of the converter 9 is connected to the fuel pipe 26, and the outlet of the converter 9 is connected to at least one fuel spray nozzle 7 of the combustion engine 1, e.g. through a pipeline. .

[0053] In various embodiments, as a result of the conversion carried out by the converter 9, the physical characteristic of the alcohol-water mixture has been changed to become the activated alcohol-water mixture having an active property. The active property may be represented by weaker atom links of alcohol and water in the activated alcohol-water mixture which are easier to be broken and easier to produce hydrogen thereby. In various embodiments, the activated alcohol-water mixture from the converter 9 may be supplied to the combustion engine 1, so that the activated alcohol-water mixture with weak atom links may be easily converted into the hydrogen rich gas in the combustion engine 1.

[0054] The converter 9 may include a converter temperature sensor 18, which is electrically connected to the ECU 16. The converter temperature sensor 18 may be configured to sense the temperature inside the converter 9, or to sense the temperature of the activated alcohol-water mixture at the outlet of the converter 9. The signal from the converter temperature sensor 18 may be received by the ECU 16 for the ECU 16 to control the operation of the at least one fuel spray nozzle 7 so as to control the supply of the activated alcohol-water mixture to the combustion engine 1.

[0055] Fig. 6 shows an enlarged view of the combustion engine unit 1 according to various embodiments. The combustion engine unit 1 includes an air intake manifold assembly 30 and an exhaust assembly 50 attached to the main body of the combustion engine 1.

[0056] The air intake manifold assembly 30 may include an air cleaner 32 connected to an inlet of the intake manifold 5, the intake manifold 5, and a throttle valve 36 disposed in the intake manifold 5. The throttle valve 36 may be electrically connected to the ECU 16, and may be controlled by the ECU 16 to determine the amount of air supplied from the air cleaner 32 to the intake manifold 5.

[0057] The intake manifold 5 may include a plenum 37 and a plurality of intake manifold runners 6. The number of intake manifold runners 6 may correspond to the number of cylinders in the combustion engine 1. The plenum 37 includes an air chamber, which is connected to the intake manifold runners 6. The throttle valve 36 may be provided in the air chamber. The intake manifold runners 6 are connected to the combustion engine 1.

[0058] The combustion engine 1 may be an internal combustion engine, such as a gasoline engine or a diesel engine. The combustion engine 1 may include a plurality of cylinders 20, with a piston (not shown) in each cylinder 20 defining a combustion chamber between a cylinder head and the piston. In the embodiments shown in Fig. 6, four cylinders 20 are included, but it is understood that the combustion engine 1 may include any number of cylinders in various embodiments. The gas fuel from the gas fuel tank 3, optionally mixed with the intake air from the intake manifold runners 6, may be supplied to the combustion chamber of the combustion engine 1. The activated alcohol-

water mixture may be supplied to the combustion chamber of the combustion engine 1 through the fuel spray nozzle 7 and may be changed to hydrogen-rich gas inside the cylinder 20.

[0059] In various embodiments, the activated alcohol-water mixture provided according to various embodiments may be easily converted to hydrogen-rich gas under normal working conditions of the combustion engine 1, due to its active property with weak atom links. In various embodiments, the activated alcohol-water mixture may be converted to hydrogen-rich gas during a compression cycle of the combustion engine 1 wherein the piston moves upward to reduce the volume of the combustion chamber. During the upward movement of the piston toward the position of a top dead center in the compression cycle, the pressure in the combustion engine is increasing, and the activated alcohol-water mixture may be converted to hydrogen-rich gas under the high temperature and high pressure inside the combustion chamber. The hydrogen-rich gas generated in the combustion engine 1 may include hydrogen gas, and may include one or more of other gases, such as carbon monoxide (CO), carbon dioxide (CO₂) and methane (CH₄). The gas fuel from the gas fuel tank 3, the hydrogen-rich gas generated in the combustion engine 1 and/or air may be burnt by the spark plug 19 by way of ignition in each combustion chamber, wherein the spark plug 19 may be electrically connected to and controlled by the ECU 16.

[0060] After the combustion in the combustion chamber, exhaust gas may be exhausted from exhaust ports of the combustion engine 1 to the exhaust manifold assembly 50. The exhaust assembly 50 may include an exhaust manifold 52 and an exhaust pipe 4.

[0061] The exhaust manifold 52 may include a plurality of exhaust manifold runners 53 and an exhaust chamber 57. The exhaust manifold runners 53 extend from the corresponding exhaust ports of the cylinders 20 to the exhaust chamber 57. The exhaust chamber 57 is connected to the exhaust pipe 4, which has an outlet for output of exhaust gas.

[0062] In various embodiments, exhaust heat of the combustion engine 1 may be used to convert the activated alcohol-water mixture to hydrogen gas. In various embodiments, heat from the cooling water of the combustion engine 1 is used. In various embodiments, exhaust heat inside the cylinder may also be used. Since the exhaust heat of the combustion engine 1 is used directly, the temperature of the combustion engine 1 may be lower and oxynitride (NO) may not exist in the exhaust gas.

[0063] Figs. 7 - 9 illustrate a cross-sectional view, an isometric view, and an exploded view and of a converter according to various embodiments.

[0064] Fig. 7 shows a cross-sectional view of the converter 9 according to various embodiments. The catalytic converter 9 is configured to facilitate hydrogen generation process, which converts the alcohol-water mixture to the activated alcohol-water mixture in the presence of catalysts.

[0065] As shown in Figs. 7 – 9, the converter 9 includes a main body 90 with two inlets and two outlets at each end of the main body 90. The converter 9 may include an inner tube 92, and an outer case 91 surrounding and enclosing the inner tube 92. The outer case 91 of the converter 9 is provided with the first inlet 921 and the first outlet 922, wherein a first tube nozzle 91a may be provided at the first inlet 921 and a second tube nozzle 91b may be provided at the first outlet 922 for controlling the flow of the

alcohol-water mixture or the activated alcohol-water mixture. The inner tube 92 may be provided with the second inlet and the second outlet.

[0066] Catalyst may be deposited at the inner walls of the inner tube 92, e.g. at the inner walls of a plurality of inner tube holes in the inner tube 92. The catalyst may be a hydrogen-generating catalyst. The catalyst may be a high temperature zinc chromium based catalyst, or may include precious metal, such as Palladium or platinum. The alcohol-water mixture flows into the inner tube 92 via the first tube nozzle 91a, and the physical characteristic of the alcohol-water mixture is changed in the inner tube 92, e.g. via the function of catalysts. The activated alcohol-water mixture with weaker atom links as a result of change of its physical characteristic flows out of the inner tube 92 via the second tube nozzle 91b.

[0067] In various embodiments, the converter 9 may include a layer of electromagnetic coils 93, which may surround the inner tube 92. The electromagnetic coils layer 93 connected to the ECU 16. The electromagnetic coils may be charged to produce a magnetic field under the control of the ECU 16, e.g., by receiving a DC current from the ECU 16, such that the converter 9 may convert the alcohol-water mixture to the activated alcohol-water mixture under the magnetic field in a more effective manner.

[0068] The outer case 91 may be a cylinder connected with the first tube nozzle 91a and the second tube nozzle 91b. The outer case 91 may include one or more parts. In various embodiments, the outer case 91 include two parts, e.g. two pieces of essentially equal semi-cylindrical covers. Each half cover is attached with fixing lugs, respectively. These covers are pressed and snapped together face-to-face by fastening the fixing lugs, for example, using bolts.

[0069] The inner tube 92 may be fixed inside the outer case 91, and the two end of the inner tube 92 and of its inner tube holes are connected to the first tube nozzle 91a and the second tube nozzle 91b, respectively.

[0070] In various embodiments, the converter 9 may include an inlet 931 for cooling water of the combustion engine to flow into the converter 9, and an outlet 932 for cooling water of the combustion engine to flow out of the converter 9. The outer case 91 may be connected with a cooling water pipe of the combustion engine, for example.

[0071] In various embodiments, cooling water of the combustion engine 1 may be received in the outer case 91 and surround the inner tube 92 to act as a heat source for supplying heat to the inner tube 92. The cooling water of the combustion engine 1 may have a temperature of more than 90°C, for example. The heat from the cooling water of the combustion engine 1 raises the temperature of the inner tube 92 to a working temperature within a desired operating temperature range. At the working temperature, the conversion process may be performed within the converter 9 to obtain the activated alcohol-water mixture, under the cooperation of catalysts deposited within the inner tube 92. The operating temperature range may be between 55 °C and 95°C.

[0072] According to various embodiments, by providing alcohol-water mixture (e.g. a mixture of ethanol and water) to the fuel tank 2 and flowing the alcohol-water mixture through the converter 9, the cooling water of combustion engine from 931 allows the inner tube 92 of the converter 9 to be heated and the catalyst on the inner walls of the inner tube may take effect to change the physical characteristics of the alcohol-water mixture. Electromagnetic effect produced by electromagnetic coils 93 may be utilized to change the physical characteristics of the alcohol-water mixture more effectively. The

activated alcohol-water mixture may be supplied from the fuel spray nozzle 7 into the combustion chamber of the combustion engine 1, and may be changed to hydrogen rich gas to be burnt by the spark plug 19 by way of ignition. At the same time or during the cold start-up phase of the combustion engine 1, the intake air from the intake manifold runners 6 mixed with the hydrogen gas from the gas tank 3 may also be burnt in the combustion chamber.

[0073] The converter temperature sensor 18 may be provided at the outlet 922. The converter temperature sensor 18 may be attached to the second tube nozzle 91b.

[0074] The converter temperature sensor 18 is configured to measure the working temperature inside the catalytic converter 9, or measure the temperature of the activated alcohol-water mixture generated by the converter 9. If the working temperature is detected to be outside a desired operating range, the converter temperature sensor 18 may send a detection signal to the ECU 16 for the ECU 16 to control the operation of fuel spray nozzle 7, so as to control the supply of the activated alcohol-water mixture to the combustion engine 1. By way of example, during a cold start-up stage of the combustion engine, the cooling water of the combustion engine may be cold at a low temperature and accordingly the converter 9 is not heated to a predetermined working temperature for conversion of the alcohol-water mixture to the activated alcohol-water mixture. The converter temperature sensor 18 may detect that the temperature in the converter 9 is not a predetermined working temperature, and accordingly the at least one fuel spray nozzle 7 may be closed to block fluid flow from the converter 9 to the combustion engine 1. Gas fuel from the gas fuel tank 3 may be supplied to the combustion engine 1. When the converter temperature sensor 18 detect that the temperature in the converter 9 is a

predetermined working temperature, e.g. above 55°C, the converter 9 may work to supply activated alcohol-water mixture and the at least one fuel spray nozzle 7 may be open.

[0075] A cross-sectional view of the inner tube 92 is shown in Fig. 10. The inner tube 92, which forms the central portion of the main body 90, has a columnar structure 92a and a plurality of inner tube holes 92b. The columnar structure 92a may be made of copper, stainless steel or corrosive-resistant cast iron. The inner tube holes 92b are deposited with catalysts on their inner walls. The catalysts may be hydrogen-generating catalyst. The catalyst may be a high temperature zinc chromium based catalyst, or may include precious metal, such as Palladium or platinum. The inner tube holes 92b may be evenly distributed within the inner tube 92 as shown in Fig. 8, or may be randomly distributed within the inner tube 92.

[0076] In various embodiments above, the engine controller 112 or ECU 16 is configured to control the solenoid valve 12 in accordance with the temperature and pressure signals from the temperature and pressure sensor 15. In various embodiments above, the engine controller 112 or ECU 16 is configured to control the electromagnetic coils 93 of the converter 9 to produce a magnetic field. In various embodiments above, the engine controller 112 or ECU 16 is configured to control the operation of the fuel spray nozzle 7 so as to control the supply of the activated alcohol-water mixture to the combustion engine 1 based on signals from the converter temperature sensor 18. In various embodiments, the engine controller is configured to control the spark plug 19. According to various embodiments, the engine controller 112 or ECU 16 is configured to control the supply of the gas fuel and the supply of the activated alcohol-water mixture in various manners depending on various needs.

[0077] Various embodiments use hydrogen gas and a mixture of alcohol and water as fuels for an engine. The main product of the combustion of hydrogen gas and alcohol-water mixture is water. Accordingly, exhaust gas emitted by the engine system reduces pollution and may be close to zero-pollution.

[0078] While the invention has been particularly shown and described with reference to specific embodiments, it should be understood by those skilled in the art that various changes in form and detail may be made therein without departing from the spirit and scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

Claims

What is claimed is:

1. A fuel system for a combustion engine, comprising:
a fuel supply configured to supply an alcohol-water mixture; and
a converter configured to convert the alcohol-water mixture received from the fuel supply to an activated alcohol-water mixture, and supply the activated alcohol-water mixture to the combustion engine.
2. The fuel system of claim 1, further comprising:
a gas fuel supply configured to supply a gas fuel to the combustion engine.
3. The fuel system of claim 2, wherein
the gas fuel comprises hydrogen gas.
4. The fuel system of claim 2, wherein
the gas fuel comprises at least one of hydrogen gas, carbon monoxide, carbon dioxide or methane.
5. The fuel system of any one of claims 1 to 4, wherein
the alcohol-water mixture comprises an ethanol-water mixture or a methanol-water mixture.

6. The fuel system of any one of claims 1 to 5, wherein
the fuel supply comprises a fuel tank configured to store the alcohol-water
mixture.
7. The fuel system of any one of claims 1 to 6, wherein
the converter is a catalytic converter.
8. The fuel system of any one of claims 1 to 7, wherein
the converter comprises an inner tube, the inner tube having a plurality of inner
tube holes for receiving catalyst on the inner wall of the inner tube holes.
9. The fuel system of claim 8, wherein
the inner tube holes extend longitudinally along the inner tube.
10. The fuel system of claim 8 or 9, wherein
the converter is configured to use cooling water of the combustion engine to heat
the inner tube.
11. The fuel system of claim 10, wherein
the converter is configured to heat the inner tube to a temperature between 55°C
and 95 °C.

12. The fuel system of any one of claims 1 to 11, wherein
the converter is configured to receive heat transferred from exhaust of the
combustion engine.
13. The fuel system of any one of claims 1 to 12, wherein
the converter comprises a layer of electromagnetic coils, the converter being
configured to convert the alcohol-water mixture to the activated alcohol-water
mixture under a magnetic field produced by the electromagnetic coils.
14. The fuel system of claim 13, wherein
the layer of electromagnetic coils is connected to an engine controller.
15. The fuel system of any one of claims 1 to 14, wherein
the converter comprises an outer case, the outer case being connected with a
cooling water pipe of the combustion engine.
16. The fuel system of claim 15, wherein
the outer case comprises a first part and a second part, the first part and the second
part being snapped together by fastening a fixing lug of the first part with a fixing
lug of the second part.
17. The fuel system of any one of claims 1 to 16, wherein

the converter is configured to connect to at least one fuel spray nozzle of the combustion engine, so as to supply the activated alcohol-water mixture to the combustion engine via the at least one fuel spray nozzle.

18. The fuel system of claim 17,
wherein the converter comprises a converter temperature sensor, and the at least one fuel spray nozzle is controlled by an engine controller based on signals from the converter temperature sensor.
19. The fuel system of any one of claims 2 to 18, wherein
the gas fuel supply comprises a gas fuel tank configured to store the gas fuel, a gas injector track configured to receive the gas fuel from the gas fuel tank via a pipeline, and at least one valve disposed along the pipeline.
20. The fuel system of claim 19, wherein
the at least one valve is controlled by an engine controller so as to control the supply of the gas fuel from the gas fuel tank to the gas injector track.
21. The fuel system of claim 19 or 20, wherein
the gas injector track is configured to supply the gas fuel to the combustion engine via at least one gas nozzle mounted on the gas injector track, the gas nozzle being configured to be connected with an intake manifold of the combustion engine.

22. The fuel system of any one of claims 19 to 21,
wherein the gas injector track comprises a pressure and temperature sensor,
wherein the at least one valve of the first fuel supply is controlled by an engine
controller based on signals from the pressure and temperature sensor.
23. The fuel system of any one of claims 2 to 22, wherein
the fuel system is controlled by an engine controller such that only the gas fuel is
supplied to the combustion engine during a cold start-up phase of the combustion
engine.
24. The fuel system of any one of claims 1 to 23, wherein
the activated alcohol-water mixture is converted into a hydrogen rich gas in the
combustion engine.
25. An engine system, comprising:
a fuel system according to any one of claims 1 to 24;
a combustion engine configured to receive the activated alcohol-water mixture
from the fuel system and convert the activated alcohol-water mixture into a
hydrogen rich gas; and
an engine controller configured to control the supply of the activated alcohol-
water mixture to the combustion engine.
26. The engine system of claim 25, wherein

the combustion engine is an internal combustion engine.

27. The engine system of claim 25 or 26,
wherein the combustion engine comprises at least one combustion chamber and a spark plug for each combustion chamber, wherein the engine controller is configured to control the spark plug.
28. The engine system of any one of claims 25 to 27, wherein
the engine controller is configured to control electromagnetic coils of the converter to produce a magnetic field.
29. The engine system of any one of claims 25 to 28, wherein
the engine controller is configured to control at least one fuel spray nozzle of the combustion engine based on signals from a converter temperature sensor so as to control the supply of the activated alcohol-water mixture to the combustion engine, the converter temperature sensor being comprised in the converter.
30. The engine system of any one of claims 25 to 29, wherein
the engine controller is configured to control at least one valve so as to control the supply of a gas fuel from a gas fuel tank to the combustion engine, the at least one valve being disposed along a pipeline connected with the gas fuel tank.
31. The engine system of claim 30, wherein

the engine controller is configured to control the at least one valve based on signals from a pressure and temperature sensor, the pressure and temperature sensor being comprised in a gas injector track connected to the gas fuel tank via the pipeline.

32. The engine system of claim 30 or 31, wherein
the engine controller is configured to control the supply of the gas fuel and the activated alcohol-water mixture such that only the gas fuel is supplied to the combustion engine during a cold start-up phase of the combustion engine.