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(54) Titre : INJECTEUR DE CARBURANT GAZEUX AUTO-INFLAMMABLE POUR MOTEUR A COMBUSTION INTERNE
(54) Title: SELF-IGNITING GASEOUS FUEL INJECTOR FOR INTERNAL COMBUSTION ENGINE

(57) **Abrégé/Abstract:**

A self-igniting gaseous fuel injector, comprising a fuel injector and a radical generator in this invention, injects a fuel to combustion chamber (cylinder) of an internal combustion engine at prescribed variable or non-variable pressure and quantities and predetermined timing intervals through single or multiple ports. The radical generator produces radicals/ions at predetermined timing and concentrations by breaking the fuel molecules before injection of the fuel into the cylinder and it reacts and ignites itself with the cylinder air or prescribed cylinder mixture as it enters into the cylinder with or without external igniting sources which can be located in an appropriate part of the cylinder. The radical generator can be electrical spark discharge type or plasma reactor type or electric-magnetic type (including micro-wave type) that is primarily used to break molecules of the fuel into radicals/ions at prescribed amounts and timing. The fuel can be gaseous fuels or liquid fuel vapors or mixtures of gaseous fuels or mixtures of gaseous fuels and liquid fuel vapors. The radical generator is positioned at prescribed location and in predetermined shape in the fuel injection system.



ABSTRACT

A self-igniting gaseous fuel injector, comprising a fuel injector and a radical generator in this invention, injects a fuel to combustion chamber (cylinder) of an internal combustion engine at prescribed variable or non-variable pressure and quantities and predetermined timing intervals through single or multiple ports. The radical generator produces radicals/ions at predetermined timing and concentrations by breaking the fuel molecules before injection of the fuel into the cylinder and it reacts and ignites itself with the cylinder air or prescribed cylinder mixture as it enters into the cylinder with or without external igniting sources which can be located in an appropriate part of the cylinder. The radical generator can be electrical spark discharge type or plasma reactor type or electric-magnetic type (including micro-wave type) that is primarily used to break molecules of the fuel into radicals/ions at prescribed amounts and timing. The fuel can be gaseous fuels or liquid fuel vapors or mixtures of gaseous fuels or mixtures of gaseous fuels and liquid fuel vapors. The radical generator is positioned at prescribed location and in predetermined shape in the fuel injection system.

Title of Invention: Self-igniting gaseous fuel injector for internal combustion engine

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Description of the Invention***Field of the invention:***

This invention relates to fuel injector for internal combustion engines for delivering particularly gaseous fuel to an engine.

Background of the invention:

Fuel injection system is used to deliver fuel to internal combustion engines. Majority of injection systems is designed to deliver liquid conventional fuels such as gasoline and diesel fuels. Engines that runs in alternative fuels such as natural gas and propane have been also developed. Majority of these alternative fuel engines is spark ignition type or dual fuel engine type that runs on diesel and a gaseous fuel such as propane or natural gas. Generally, in dual fuel engines, diesel fuel is used as a pilot igniter for gaseous fuel mixture inside the engine cylinder. In these engines, the gaseous fuel is either injected through the same injector as of diesel or a separate injector or a injector that is located at intake manifold or intake valve. Conversion kits have also been developed for converting gasoline or diesel (liquid fuel) engines to natural gas or propane (gaseous fuel). Generally these conversion kits comprise a fuel/air mixer system for delivering the gaseous fuel to the engine cylinder.

Disclosure of the Invention:

The present invention of a new concept of fuel injectors that provides a self-igniting gaseous fuel at the predetermined pressure, ways and parts of injection of a fuel into an engine cylinder is disclosed. This avoids the necessity of injecting diesel fuel to provide pilot into a dual fuel engine which is a general case. Hence, there will be no need to have two separate fuel supply systems in these engines and the engine will run just like a diesel engine (compression ignition engine) only with gaseous fuel injection.

The present invention of a self-igniting gaseous fuel injector is comprised of a fuel injector and a radical generator. The fuel injector injects a fuel to combustion chamber (cylinder) of an internal combustion engine at prescribed variable or non-variable pressure and quantities and predetermined timing intervals through single or multiple ports. The radical generator produces radicals at predetermined timing and concentrations by breaking the fuel molecules before injection of the fuel into the

cylinder so that it can react and ignite itself with the cylinder air or prescribed cylinder mixture as it enters into the cylinder with or without external igniting sources which can be located in an appropriate part of the cylinder. The radical generator can be electrical spark discharge type or plasma reactor type or electric-magnetic type (including microwave type) that is primarily used to break molecules of the fuel into radicals at prescribed amounts and timing. The fuel can be gaseous fuels or liquid fuel vapors or mixtures of gaseous fuels or mixtures of gaseous fuels and liquid fuel vapors. The radical generator is positioned at prescribed location and in predetermined shape in the fuel injection system.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a view schematically showing a specific system for fuel supply of an internal combustion engine in accordance with the present invention, which operates with the use of an inventive method; and

Figure 2 is a view schematically showing a basic system for fuel supply of an internal combustion engine in accordance with the present invention which operates with the use of an inventive method.

DISCRIPTION OF PREFERRED EMBODIMENTS

A fuel supply system in accordance with the present invention which operates in accordance with the inventive method is used for supplying fuel to an internal combustion engine, for example a compression ignition or a dual fuel engine 9. The system includes a high pressure fuel tank 1 for storing fluid fuel such as natural gas or hydrogen or propane or any gaseous fuel. A control valve or similar device 3 controls supply of the fuel from the gas tank 1 to the internal combustion engine. The engine is provided with intake manifold system 7 with throttle 7 (optional) and an exhaust system 10. In the case of modern closed loop engine, the exhaust system 10 includes an exhaust gas oxygen sensor which outputs an information about oxygen content in the exhaust gases on a signal line. Although it is illustrated as a closed-loop control system, the electronic control unit 6 in accordance with the present invention can be used to operate with engines which are opened-looped and do not have an exhaust gas oxygen sensor.

The engine in accordance with the present invention is equipped with fuel injection system which includes a radical/ion generator 4 and a injector or a nozzle 5. However, the preferred embodiment is described with a direct-in-cylinder injection system it may equally be suited to operate with a carbureted or an intake manifold injection.

The electronic unit 6 accepts inputs from several sensors including from operator accelerator paddle 11 and it outputs control signals to valve 3 and or injector 5 which can be formed as normally closed fuel-gas control solenoid valve. It also outputs control signals to the radical and or ion generator control module 4. In principle, the radical and or ion generator and the injector may incorporated in one unit. During the operation the electronic control unit may receive signals from an engine coolant temperature sensor, an intake air temperature sensor, an engine speed sensor, a throttle position sensor (optional), a manifold pressure sensor, a fuel pressure sensor, an accelerator pedal sensor and a battery voltage sensor. For optimal performance it is preferable that the electronic control unit also receives input from one or several other sensors such as exhaust gas oxygen sensor, a mass air flow sensor, a barometric sensor, and an exhaust gas recirculation sensor if the engine has exhaust recirculation capabilities. Also other sensors can be used for sensing other operating parameters.

As shown in Figure 1, the electronic control unit receives a number of signals from sensors which monitor selected operating conditions the engine 9, and in turn sends a signal to the control valves 3 and a signal to radical/ion generator 4 and or injector or nozzle if needed which supply the compressed high pressure gaseous fuel to the cylinder. A pressure regular 2 may be used to supply the fuel at predetermined pressure. As the fuel is supplied at or near top dead center, a high pressure fuel system is needed. In case, if fuel pressure available in the tank is not enough, a pressuring system may be included. If liquified gaseous fuel is supplied a liquid pressure pump and evaporator may be incorporated. The output signal from the electronic control unit 6 to the valve 3 and radical/ion generator and or injector may be a pulse-width modulation signal over a fuel

injection fuel line to control the injection of the fuel. However other types of control methods and other forms of fuel delivery may be utilized.

The duration of opening and the time of opening for the control valve 3 and or radical/ion generator 4 and or injector 5 are determined by a series of computations performed by the electronic control unit 6, using as inputs the signals delivered by the various sensors described above. The activation of the radical/ion generator allows to break down the molecule of fuel into many types of radicals and ion particles that ignites as it enters into the engine cylinder and helps ignite the fuel injected. This provides the uniqueness of this invention that no spark ignition system is needed and the fuel can be ignited as diesel fuel in compression ignition type engines. For an example, this avoids the use of diesel pilot in dual fuel engines and these engines can be run on the gaseous fuel just as diesel engines. The radical/ion generator may consist of a power supply unit and a radical/ion producer such as a plasma generator, a micro-wave-producer and or a powerful spark discharge. To reduce the power requirement and improve the effectiveness of radical/ion generator an additive may be used in the fuel supply system.

While the invention has been illustrated and described as embodied in method of and system for fuel supply for an internal combustion engine, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the following will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

What is claimed as new and desired to be protected by Letters of Patent is set forth in the appended claims.

CLAIMS

1. A method of a fuel supply for an internal combustion engine, comprising the steps of providing a source of a fluid fuel and radical/ion in predetermined quantities and predetermined ways which are determined in correspondence with sensed operational parameter of the internal combustion engine so as to provide fuel and radical/ion mixture to be supplied to the internal combustion engine.
2. A method as defined in claim 1; wherein said sensing of an operational parameter includes a sensing selected from the group consisting of sensing an engine coolant temperature, an intake air temperature, an engine speed, a manifold pressure, a fuel pressure, a battery voltage, an exhaust gas oxygen composition, a knocking, a mass air flow and an exhaust gas recirculation.
3. A method as defined in claim 1; and further comprising providing a fuel metering means for the fuel located downstream of said source and a regulator so as to provide the fuel at predetermined pressure.
4. A method as defined in claim 1; and further comprising a pressure boosting pump and or evaporator if the fuel is supplied in liquid form.
5. A method as defined in claim 1; wherein said radical/ion are generated by breaking the fuel molecules into various radical and or ion which are more prompt to chemical reaction and provide ignition of the fuel and oxidant mixture, and said radical/ion generator may be consist of a radical/ion generator unit and a power supply unit.
6. A method as defined in claim 5; further comprising a system that provides a necessary quantities at predetermined time of radical and or ion in order to provide ignition of the fuel in the combustion chamber of the internal combustion engine.
7. A method as defined in claim 5; wherein said radical/ion generator system may be of various types such as a thermal or non thermal plasma type, a microwave type and, a spark discharge type that are capable to provide predetermined amount of such radical and or ion at predetermined time and duration.
8. A method as defined in claim 1; and further comprising an injection nozzle or injector to provide the fuel and radical/ion mixture into the cylinder of the engine at predetermined pressure and temperature and predetermined ways.

9. A method as defined in claim 1; and further comprising a provision to supply an additive in order to reduce the power requirement of and improve efficiency of radical and or ion generator.
10. A method as defined in claim 1; and further comprising providing assistance from such as glow plug, or heat surface or spark igniter to ignite the fuel and radical/ion mixture in the combustion chamber in the internal combustion engine.
11. A system of a fuel supply for an internal combustion engine, comprising the steps of providing a source of a fluid fuel and radical/ion in predetermined quantities and predetermined ways which are determined in correspondence with sensed operational parameter of the internal combustion engine so as to provide fuel and radical/ion mixture to be supplied to the internal combustion engine.
12. A system as defined in claim 11; wherein said sensing of an operational parameter includes a sensing selected from the group consisting of sensing an engine coolant temperature, an intake air temperature, an engine speed, a manifold pressure, a fuel pressure, a battery voltage, an exhaust gas oxygen composition, a knocking, a mass air flow and an exhaust gas recirculation.
13. A system as defined in claim 11; and further comprising providing a fuel metering means for the fuel located downstream of said source and a regulator so as to provide the fuel at predetermined pressure.
14. A system as defined in claim 11; and further comprising a pressure boosting pump and or evaporator if the fuel is supplied in liquid form.
15. A system as defined in claim 11; wherein said radical/ion are generated by breaking the fuel molecules into various radical and or ion which are more prompt to chemical reaction and provide ignition of the fuel and oxidant mixture, and said radical/ion generator may be consist of a radical/ion generator unit and a power supply unit.
16. A system as defined in claim 15; further comprising a system that provides a necessary quantities at predetermined time of radical and or ion in order to provide ignition of the fuel in the combustion chamber of the internal combustion engine.
17. A system as defined in claim 15; wherein said radical/ion generator system may be of various types such as a thermal or non thermal plasma type, a microwave type and, a spark discharge type that are capable to provide predetermined amount of such radical and or ion at predetermined time and duration.

18. A system as defined in claim 11; and further comprising an injection nozzle or injector to provide the fuel and radical/ion mixture into the cylinder of the engine at predetermined pressure and temperature and predetermined ways.
19. A system as defined in claim 11; and further comprising a provision to supply an additive in order to reduce the power requirement of and improve efficiency of radical and or ion generator.
20. A system as defined in claim 11; and further comprising providing assistance from such as glow plug, or heat surface or spark igniter to ignite the fuel and radical/ion mixture in the combustion chamber in the internal combustion engine.

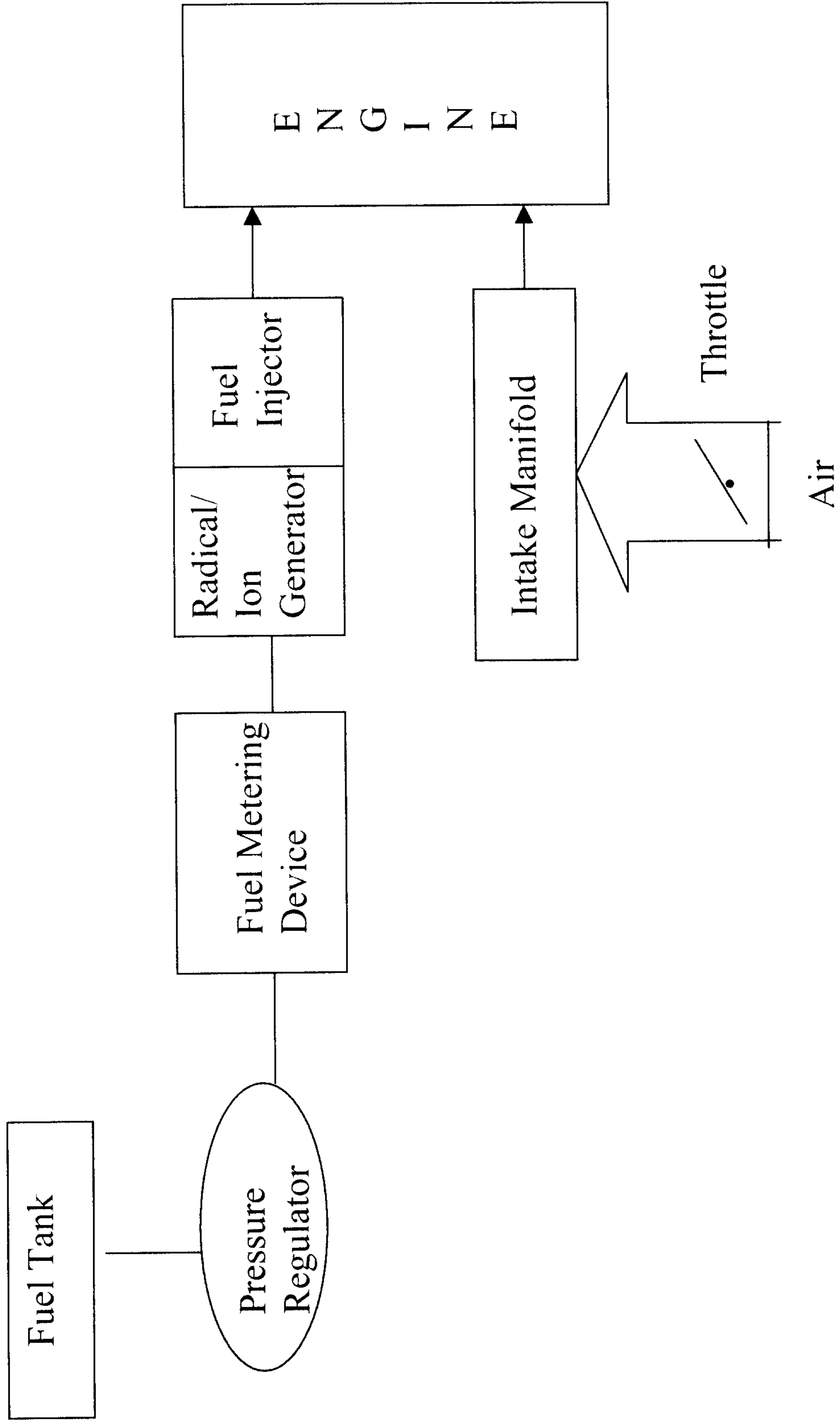


Figure 2