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DUAL FUEL INJECTION

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(57) Claim

1 A dual fuel injection arrangement for an internal combustion engine comprising a single fuel rail system supplying either a first fuel or a second fuel to at least one injector to inject fuel into an inlet manifold of the engine and an electronic control unit arrangement acting upon engine parameters and demand parameters for the first fuel or the second fuel to determine injector timing for the first fuel or the second fuel wherein the first fuel is petrol and the second fuel is LPG and the second fuel is operated at a higher pressure than the first fuel

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COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

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Invention Title:

DUAL FUEL INJECTION

Details of Associated Applications:

90155/91 and 90192/91 made by BIOCOM PTY LTD

The following statement is a full description of this invention, including the best method of performing it known to us:

FIELD OF THE INVENTION

This invention relates to fuel injection internal combustion engines and the operation of such an engine on two different fuels.

The invention will be generally discussed in relation to the operation of a vehicle on petrol and liquefied petroleum gas as fuels but the invention is not restricted to these two fuels.

BACKGROUND OF THE INVENTION

It is particularly desirable on the grounds of economics when manufacturing or adapting an engine to run on two fuels to have only one set of fuel injectors for the two fuels and this presents the problem that there must be some way of separating the two fuels and also to provide the ability to change injection timing to ensure that the correct amount of fuel enters the engine with the alternative fuels.

If one investigates petrol and LPG it can be noted that on a gravimetric basis propane which is the predominant component in LPG contains 6% more energy than petrol whereas on a volumetric basis petrol contains 35% more energy than propane. It is necessary to operate the two fuels in the dual fuel engine arrangement at different pressures to ensure that they both remain liquid and even so different injection timings are necessary. In such a system for instance petrol may be supplied to the engine at 250 kilopascals whereas LPG may be supplied to the engine in a pressure range of from 300-2000 kilopascals.

Another problem with fuel injection systems which this invention may solve is the problem of heating of the injectors due to heat of the engine with consequent vapourisation in the injector before injection.

The engine control computer, the electronic control unit (ECU), in a petrol driven vehicle is arranged to provide an electrical signal to activate the or each injector to provide the required amount of fuel to efficiently combine with the amount of air

and in particular oxygen allowed into the engine by the throttle setting. The optimum amount of fuel varies with air and engine temperatures, running conditions demanded such as engine speed, acceleration, steady running for economy and the like. The typical computer system has inputs sensing engine speed, throttle position, air temperature, engine temperature, manifold or inlet air pressure, air-conditioner condition and whether at idle or over-run etc. All such inputs along with a feed back input from an oxygen sensor sensing the actual combustion conditions as detected in the exhaust system combine to allow the computer to optimise the quantity of fuel admitted to the engine.

The fuel admission to each cylinder is controlled by an electric valve, an injection valve, which admits fuel under pressure to the inlet manifold of the engine for as long as the valve is opened. The actual time of opening may be adjusted to allow for opening or closing delays so that a selected amount of fuel is injected.

BRIEF SUMMARY OF THE INVENTION

This present invention provides an arrangement whereby such an engine can be arranged and supplies a control arrangement for such an engine.

In one form therefore the invention is said to reside in a dual fuel injection arrangement for an internal combustion engine comprising a single fuel rail system supplying either a first fuel or a second fuel to at least one injector to inject fuel into an inlet manifold of the engine and an electronic control unit arrangement acting upon engine parameters and demand parameters for the first fuel or the second fuel to determine injector timing for the first fuel or the second fuel wherein the first fuel is petrol and the second fuel is LPG and the second fuel is operated at a higher pressure than the first fuel.

Preferably the or each injector may be of a bottom feed type of injector and excess of either the first or the second fuel may be recirculated through the injectors to cool the injectors.

Further the or each injector may be of a bottom feed flow through type of injector and excess of either the first or the second fuel may be recirculated through the injectors to cool the injectors.

The single fuel rail system may comprise an inlet rail directed towards the or each injector and an outlet rail extending from the or each injector.

In one embodiment the inlet rail has a first fuel inlet and a second fuel inlet and the outlet rail has a first fuel outlet and a second fuel outlet, a solenoid valve on the second fuel inlet and the first fuel outlet and a non-return valve on the first fuel inlet and the second fuel outlet and wherein the arrangement is operated with the second fuel at a higher pressure than the first fuel. As the flow through injectors make an open connection between the inlet rail and the outlet rail both rails are at substantially the same pressure. In an alternative arrangement, the inlets and outlets can be in either rail.

The fuel rail system may be of a low heat capacity construction so it can be easily cooled by a circulating flow of either the first fuel or the second fuel.

The fuel system for the second fuel may comprise a tank for the second fuel, a fuel pump to raise the pressure of the second fuel a fixed differential above the vapour pressure of the second fuel in the tank, a fuel line from the pump to the second fuel inlet, a return fuel line from the second fuel outlet to the tank and a second fuel regulator in the return fuel line.

The second fuel regulator in the return fuel line may be incorporated in the non-return valve in the second fuel outlet.

The engine parameters and demand parameters upon which the calculation of engine timing for the first fuel or the second fuel may be the pressure of the fuel and the actual composition of the fuel. In the case where the second fuel is LPG where the composition may range from 40% propane and 60% butane for Australia but can vary to any mix of butane and propane world-wide up to 100% propane and at 30 degrees Celsius for instance this may mean a range of vapour pressure from 100 kilopascals up to nearly 2000 kilopascals. It is desirable that a LPG injection arrangement operate entirely in the liquid phase hence it is

necessary to maintain the pressure of the LPG above the vapour pressure at a given temperature and as vapour pressure may rise to 1600 kilopascals at 45°C then the engine must be operated at considerably above that pressure to ensure maintenance of LPG in the liquid state.

This invention preferably provides that the injectors are of a flow-through type so that a considerable excess to the amount of fuel necessary for supplying to the engines flows through the injectors and absorbs heat and takes it away to the respective fuel tanks depending upon which fuel is being used. This will assist in prevention of vapourization of the fuel in the injector.

In one particular example for instance the ratio of circulating to used flow may range from 100:1 for idling using petrol to 3:1 using petrol at full power and for LPG there may be 230:1 circulating to used flow at idle and 7:1 circulating to used flow at full power. The actual flow rate of LPG in the system may be 270 litres per hour of liquid LPG.

The flow-through fuel injector may have an inlet near its bottom so that fuel flowing into the injector is immediately available for injection into the inlet manifold if required and internal passages can be provided in the injector to withdraw the LPG or petrol from the top of the injector to return the excess fuel to the fuel tank with heat either generated in the valve by the electric solenoid arrangement or from conduction and radiation from the engine. Such an injector may be known as a bottom feed injector.

A fuel rail for such a system therefore actually comprises an inlet rail which is directed towards each injector and an outlet rail extending from each injector. There may be first fuel and second fuel inlets into the inlet rail and first fuel and second fuel outlets from the outlet rail. In one particular embodiment there may be provided solenoid valves on the inlet for the more highly pressurised fuel and the outlet of the less pressurised fuel and non-return valves preventing flow out of the fuel rail from in the first fuel inlet and preventing flow into the outlet rail from the second fuel outlet.

The device according to this invention may be provided in a motor vehicle during manufacture or alternatively may be installed as a retro-fit item after manufacture. In such a case the electronic control unit may be replaced or an additional electronic control unit may be placed in the vehicle and connected into the electrical signal lines of the first electronic control unit to vary the injection characteristics when the device is being operated in the alternative fuel mode.

To ensure that at all times LPG is supplied to the injector arrangement in liquid form it is desirable to have the LPG fuel pump immersed or partially immersed at least on the suction side in the LPG liquid. In one preferred embodiment the housing of the pump may be designed to have the suction side of the pump immersed in liquid as a secondary tank. The differential LPG pressure relief regulator may be set so the fuel pump may operate at its maximum efficiency which provides a typical discharge pressure of 150-300 kilopascals over the vapour pressure of the liquid at a flow rate of about 250 litres per hour.

The LPG fuel circulates through a fuel filter, a solenoid valve and temperature and pressure sensors to the inlet fuel rail and on to the injectors. The LPG return may go via a non-return valve and a differential pressure relief regulator to return to the LPG tank. The non-return valve may incorporate the differential pressure relief regulator by inclusion of a spring in the non-return valve of the desired cracking pressure. The circulation flow rate may be always substantially constant but the operating LPG pressure varies depending upon the vapour pressure of the LPG in the fuel tank. Injection timing may be controlled by the LPG electronic control unit or the second electronic control unit which is provided with the same activation signals as provided for the petrol injector to compensate for the LPG energy requirements for instance for pressure, density and combustion variations. The pulse width signal for the injectors is derived using look up tables or maps stored in the respective electronic control units. Alternatively the pulse width of the injector signal for either petrol or LPG operation may be calculated using the engine variables and the the fuel variables, pressure and temperature.

The operating pressure of LPG in a typical system may vary from 400 to 2200 kilopascals depending on ambient temperature. Therefore, a number of look-up tables or maps corresponding to the various pressures may be used to calculate

the LPG injection timing. It is found the the LPG pulse will vary depending upon operating pressure but its equivalent petrol pulse is about 30 to 40% longer. It has been found that the relationship is not linear due to the opening and closing times of the injector at short and long pulse widths as well as the higher operating pressures of LPG in comparison to petrol. During idling a petrol pulse width is about 4 milliseconds whereas an LPG pulse width is in the order of 2.0 to 2.5 milliseconds depending on the operating pressures. At full power maximum pulse width of petrol pulse is about 27 milliseconds for some vehicles going down to 18 milliseconds for others at normal engine temperatures whereas an LPG pulse width is in the order of 11 to 14 milliseconds depending on the vehicle and the operating pressures.

DETAILED DESCRIPTION

This then generally describes the invention but the invention will now be discussed in relation to a preferred embodiment as shown in the accompanying drawings in which:

FIGURE 1 shows a stylized dual fuel injection system for an internal combustion system.

FIGURE 1 shows an LPG/petrol dual fuel injection system installed onto an internal combustion engine for a motor vehicle but it will be realised that the invention also relates to a change over or add on kit which may be provided to connect into a motor vehicle. The system may also be used on a engine in other than a motor vehicle. The drawing generally shows an arrangement of an engine having fuel injectors with the LPG injection system shown in stylised detail and only the petrol inlet and outlets shown.

A four cylinder engine 1 has an air inlet manifold 2 and an exhaust manifold 3. Fuel injectors 4, 5, 6 and 7 are provided to inject fuel into the inlet manifold ducts to each cylinder of the engine. A fuel rail system comprises an inlet fuel rail 8 provided with branch lines 9 which extend into the bottom of the respective fuel injectors 4, 5, 6 and 7. Branch lines 10 remove excess fuel from the top of the injectors 4, 5, 6 and 7 into a outlet fuel rail 11. A petrol inlet line 12 with a non

-return valve 13 allows petrol into the inlet fuel rail 8. A LPG inlet line 14 allows LPG to enter the inlet fuel rail 8 through a solenoid valve 15. An LPG tank 16 and LPG fuel pump 17 direct fuel by means of LPG fuel line 18 to the LPG inlet 14. A non-return valve 33 in the LPG inlet line 14 prevents flow of petrol into the LPG tank when the LPG pressure is lower than the petrol pressure.

A solenoid valve 20 and pressure regulator 21 and are provided in the petrol outlet line 22 which is connected to the outlet fuel rail 11.

A non-return valve 23, solenoid valve 34 and LPG pressure regulator 24 are provided in an LPG outlet line 25 which extends also from the outlet fuel rail 11. A LPG return line 26 is provided to return fuel to the LPG tank. The non-return valve 23 and the pressure regulator 24 may be incorporated into a single device with a cracking pressure or differential pressure set at the desired pressure above the LPG vapour pressure.

A pressure sensor 27 detects fuel pressure in the fuel inlet rail and a temperature sensor 28 detects temperature of inlet fuel particularly for the LPG.

The LPG pressure regulator 24 is provided to regulate the LPG pressure at a pressure of 150-300 kilopascals above the vapour pressure of the LPG in the LPG tank.

The engine according to this invention includes an electronic control arrangement to control the injection of fuel into the engine.

In this embodiment the electronic control arrangement is divided into two separate components with a first component being the electronic control unit 31 for petrol injection and a second electronic control unit 32 being provided to calculate the injection timing pulses when the vehicle is switched to LPG operation. Both the electronic control units 31 and 32 use the various engine demand and fuel characteristics to calculate the injection timing. In situations where the system is being operated on petrol the injection signals are generated in the electronic control unit 31 and are routed through the second electronic control unit 32 without being changed.

The wires 35 which extend from the petrol injection control unit 31 are connected into the LPG control unit 32 and if LPG is being used then an LPG timing pulse for LPG is calculated or determined from look-up tables and the signal for each injector is directed to the respective electric solenoid injector valves 4, 5, 6 and 7.

It will be realised that the petrol electronic control unit and the LPG electronic control unit may be a single device adapted to provide the required timings.

On some motor vehicles only one fuel injector may be used for both petrol and LPG with injection occurring in the inlet manifold before the inlet manifold branches to the various cylinders. Similarly injector timings for 6, 8 or more cylinders can be controlled.

The method of operation of the engine according to this invention is as follows.

When the engine is being operated on petrol then the solenoid valve 15 in the LPG inlet line and solenoid valve 34 in the LPG outlet line are closed and the solenoid valve 20 in the petrol outward line 22 is open and petrol flows in a continuous flow through the inlet fuel rail to each of the injectors to cool the injectors and is used as set by the injection timing by the injectors. The engine control unit 31 provides petrol pulse signals and the LPG control unit 32 does not change the signals and directs them directly to each injector. Excess fuel is returned through outlet fuel rail 11 to petrol return line 22.

It should be noted that should the injectors be changed or altered in flow characteristics during the conversion process the LPG control can be utilized to correct for such altered characteristics when operating on petrol.

When it is desired to change over to LPG operation the petrol solenoid valve 20 is closed and the LPG solenoid valves 15 and 34 are opened and the fuel pump 17 is activated. This provides LPG sat a fixed differential pressure determined by pressure regulator 24 and the vapour pressure at the particular time to the fuel rails and once again a circulating flow is achieved with considerable excess flow to ensure cooling of the injectors. The non-return valve 13 in the petrol inlet line is set up so that LPG cannot enter the petrol inlet line and the non-return valve 23 in the LPG outlet line allows LPG to pass back to the LPG tank. The petrol pulse signals calculated in the electronic control unit 31 are ignored and LPG injection signals are calculated in the LPG electronic control unit 32 depending upon the pressure determined by pressure sensor 27 and the other input parameters 30 so that a correct calorific amount of LPG can be injected.

It will be seen that by this invention there is provided a method and an arrangement by which an existing petrol engine can be converted to dual fuel operation, for instance for petrol and LPG operation with a minimum of new components necessary and also an arrangement in which a second fuel injection system such as an injection system utilizing LPG can be installed in a motor vehicle as a dual fuel vehicle when initially sold.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1 A dual fuel injection arrangement for an internal combustion engine comprising a single fuel rail system supplying either a first fuel or a second fuel to at least one injector to inject fuel into an inlet manifold of the engine and an electronic control unit arrangement acting upon engine parameters and demand parameters for the first fuel or the second fuel to determine injector timing for the first fuel or the second fuel wherein the first fuel is petrol and the second fuel is LPG and the second fuel is operated at a higher pressure than the first fuel

2 A dual fuel injection arrangement as in Claim 1 wherein the or each injector is of a bottom feed type of injector and excess of either the first or the second fuel is recirculated through the injectors to cool the injectors.

3 A dual fuel injection arrangement as in Claim 1 wherein the or each injector is of a bottom feed flow through type of injector and excess of either the first or the second fuel is recirculated through the injectors to cool the injectors.

4 A dual fuel injection arrangement as in Claim 1 wherein the single fuel rail system comprises an inlet rail directed towards the or each injector and an outlet rail extending from the or each injector.

5 A dual fuel injection arrangement as in Claim 1 wherein the inlet rail has a first fuel inlet and a second fuel inlet and the outlet rail has a first fuel outlet and a second fuel outlet , a solenoid valve on the second fuel inlet and the first fuel outlet and a non-return valve on the first fuel inlet and the second fuel outlet.

6 A dual fuel injection arrangement as in Claim 1 wherein the fuel rail system is of a low heat capacity construction so it can be easily cooled by a circulating flow of either the first fuel or the second fuel.

7 A dual fuel injection arrangement as in Claim 1 wherein a fuel system for the second fuel comprises a tank for the second fuel, a fuel pump to raise the pressure of the second fuel a fixed differential above the vapour pressure of the second fuel in the tank, a fuel line from the pump to the second fuel inlet, a return fuel line from the second fuel outlet to the tank and a second fuel regulator in the return fuel line.

Dated this 17th day of July 1996

THE ENERGY RESEARCH AND DEVELOPMENT
CORPORATION
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ABSTRACT

A dual fuel injection arrangement for an internal combustion engine comprising a single fuel rail system supplying either a first or a second fuel to at least one injector to inject fuel into an inlet manifold of the engine. An electronic control unit acting upon engine parameters and demand parameters for the first fuel or the second fuel to determines injector timing for the first fuel or the second fuel.

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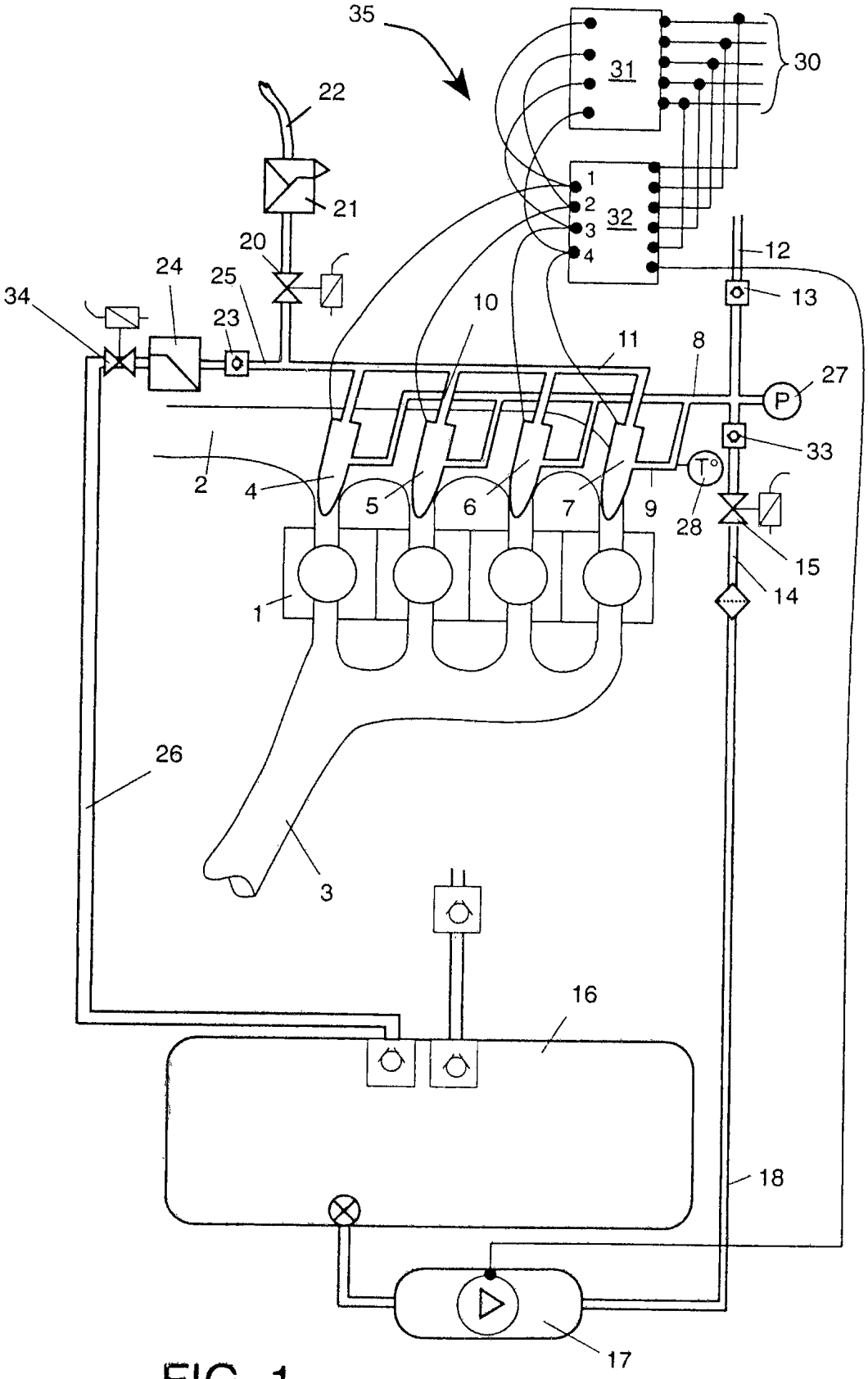

FIG. 1