

FUEL SUPPLY APPARATUS FOR AN INTERNAL COMBUSTION ENGINE

The present invention relates to fuel supply apparatus for an internal combustion engine, particularly a diesel engine.

There is prevailing concern over toxic emissions produced by vehicles and legislation throughout the world has reflected this concern by imposing limitations on engine exhaust emissions. In particular, there is strict control on the maximum amount of black smoke emitted by a diesel engine.

Black smoke or soot is produced from vehicle exhausts in certain circumstances by virtue of too much fuel being supplied to the combustion chamber of a diesel engine. Fuel which does not combust fully is emitted by the vehicle exhaust as soot or smoke. This problem is particularly prevalent during starting of the vehicle engine. The amount of fuel supplied to fuel injectors of the engine is controlled by a governor in a fuel pump. At engine cranking speed (the rotational speed of a starter motor) of typically less than 300 r.p.m. the governor is operating to attempt to supply sufficient fuel to sustain an engine idling speed of 600-700 r.p.m. So fuel in excess of the requirement is supplied until the engine has fired and reaches idle speed and consequently the excess fuel is not combusted fully and is emitted as smoke. The governor operates in this way to ensure that sufficient fuel is supplied to the engine at low idle speed to prevent engine stalling when a load is applied.

It is an object of the present invention to obviate or mitigate the aforesaid disadvantage.

According to the present invention there is provided fuel supply apparatus for an internal combustion engine, the apparatus comprising means for delivering fuel to the engine, a bleed passage along which a predetermined amount of fuel being delivered may be diverted so that it bypasses the engine and a control device for opening and closing the bleed passage as required.

The means for delivering fuel to the engine preferably comprises a fuel pump connected to fuel injectors via a main fuel conduit.

The bleed passage may be connected to the main fuel conduit so that, when open, fuel flowing from the pump to the injectors may be bled.

The bleed passage preferably has a valve which is operable in response to the control device to open or close the passage.

Preferably the control device comprises a timer operable so that the bleed passage is open for a predetermined amount of time.

The timer may operate so that the bleed passage is open for a

predetermined time during starting of the engine so that part of the fuel being delivered bypasses the engine. Thus from the time when the starting or ignition switch is operated until such time as the engine fires and reaches idling speed, fuel is bled to avoid an excess entering the engine and consequent generation of smoke.

The bleed passage may be kept open for around 2-4 seconds at starting and is then closed.

In an alternative embodiment the control device has an engine speed sensor and operates to open or close the bleed passage according to the engine speed.

Preferably the bleed passage is opened when starting the engine and is closed when the engine reaches a predetermined speed below an idling speed.

In a third embodiment the control device comprises an oil pressure sensor and operates to open or close the bleed passage according to the engine oil pressure.

The control device of each embodiment may also comprise at least one temperature sensor so that if ambient temperature and/or engine temperature is below a predetermined value the bleed passage is kept closed. This enables a rich air/fuel mixture to be supplied when starting the engine in cold conditions.

The valve is preferably a solenoid operated valve.

The bleed passage may have an orifice to control the amount of fuel that flows through the bleed passage.

Preferably the bleed passage returns the bled fuel to a fuel reservoir.

A specific embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic drawing of a diesel engine for use with the present invention.

Figure 2 is a schematic diagram of fuel supply apparatus according to the present invention;

Figure 3 shows a circuit diagram for a timer control device as one embodiment of part of the present invention; and

Figure 4 shows a graph indicating the rate of emission of black smoke of standard fuel supply apparatus compared with that of the present invention.

Referring to now to the drawings, Figure 1 shows an internal combustion diesel engine A with which the present invention may be used. Exhaust gases from the engine A pass across a turbine of a turbo charger B which drives a compressor C to pressurise air in an inlet manifold D.

Referring to Figure 2, fuel is drawn from a fuel tank 1 of a vehicle by fuel pump 2 via a filter 3 in a conventional manner.

The fuel is pumped via a first solenoid valve 4 to fuel injectors 5 which are supplied by a common fuel line 6. The injectors 5 are of known direct injection design in which a cam actuated plunger (not shown) injects fuel at high pressure into engine cylinders (not shown) for combustion.

The fuel pump 2 responds to acceleration of the vehicle by supplying fuel at the appropriate pressure to the injectors 5.

Any excess fuel not injected into the engine is returned to the tank 1 by return fuel line 7.

The fuel pump 2 has a second solenoid valve 8 which operates to open and close a bleed line 9 connected between the common fuel line and the fuel return line 7. The bleed line 9 has an orifice 10 of typically 1/8 inch diameter (0.32 cm) or 5/32 inch diameter (0.4cm) to restrict the amount of fuel that flows. The second solenoid valve 8 is controlled by an electronic timer shown in Figure 2.

The timer 11 is powered by a constant 24V DC supply and is controlled by a 24V DC relay 12 which is connected to the starter or ignition switch of the vehicle. The output of the timer 11 is connected to the solenoid valve 8 controlling the bleed line 9 and carries sufficient current to operate the valve 8. A suitable timer for this purpose is the timer relay 329 238 supplied by Radio Spares.

If a starter or ignition switch is operated to start the vehicle the timer 11 provides an output current to open the second solenoid valve 8 for a period of 2-4 seconds. After the 2-4 second period has elapsed the timer 11 reverts to a condition whereby the second solenoid valve 8 is closed.

When the second solenoid valve 8 and thus bleed line 9 are open a percentage of the fuel which is being pumped to the injectors 5 is bled off, flows along the bleed line 9 so that it bypasses the engine and is returned to the fuel tank 1 via return line 7. The percentage of fuel that is bled is controlled by the size of the orifice 10 in the bleed line 9.

When the vehicle is being started and the engine is initially cranking at the speed of the starter motor (below 300 r.p.m.), for the timed period of 2-4 seconds the bleed line 9 is open and the fuel supplied is bled to limit the amount entering the engine and thus restrict the undesirable black smoke exhaust.

Figure 4 shows a comparison of the black smoke emissions when using a conventional fuel supply arrangement and two arrangements in accordance with the present invention. The engine used in this case is a ten litre, in-line, six

cylinder type, rated at 252 bhp. The time scale indicates the time elapsed since operating the starter switch. Graph A indicates the emission levels when using a standard arrangement and it can be seen that black smoke emissions of over 90 HSU (Hartridge Smoke Units) are present within the first second.

Graph B shows the black smoke emission level for fuel supply apparatus of the present invention using a bleed orifice of 5/32 inch diameter (0.32cm) and a timer set at four seconds. In this case the emissions are kept at well below 20 HSU in the first four seconds and rise to a maximum of around 55 HSU after around 4.5 seconds

Graph C shows the emission for apparatus of the present invention when fitted with a bleed orifice of 1/8 inch diameter (0.4cm). The initial emissions within the first second reach a peak of around 25 HSU and fall to around 10 HSU until reaching a small peak at around 4.5 seconds of about 35 HSU.

It will be appreciated that the second solenoid valve in the bleed line can be controlled by means other than a timer. The valve may be opened and closed in response to the engine speed if an electronics engine management system is present. So, for example, the valve is kept open when a cranking speed of 300 r.p.m. is detected and is closed when the engine has fired i.e. when it reaches idle speed of typically 600-700 r.p.m.

As an additional feature there may be provided a temperature sensor which acts to override the bleed line valve control. If ambient temperature below a certain level is detected the bleed line is not opened as a richer fuel to air ratio will be required to start the engine in relatively cold conditions

The valve may alternatively be controlled in response to the engine oil pressure.

It will be understood that the invention is not sensitive to engine capacity and results similar to those shown in Figure 3 are anticipated on engines as both larger and smaller.

CLAIMS

1. Fuel supply apparatus for an internal combustion engine, the apparatus comprising means for delivering fuel to the engine, a bleed passage along which a predetermined amount of fuel being delivered may be diverted so that it bypasses the engine and a control device for opening and closing the bleed passage as required.
2. Fuel supply apparatus according to claim 1, wherein the means for delivering fuel to the engine comprises a fuel pump connected to fuel injectors via a main fuel conduit.
3. Fuel supply apparatus according to claim 2, wherein the bleed passage is connected to the main fuel conduit so that, when the passage is open, fuel flowing from the pump to the injectors may be bled.
4. Fuel supply apparatus according to any preceding claim, wherein the bleed passage has a valve which is operable in response to the control device to open or close the passage.
5. Fuel supply apparatus according to any preceding claim, wherein the control device comprises a timer operable so that the bleed passage is openable for a predetermined amount of time.
6. Fuel supply apparatus according to claim 5, wherein the timer operates so that the bleed passage is open for a predetermined time during starting of the engine so that part of the fuel being delivered to the engine flows into the bleed passage and bypasses the engine.
7. Fuel supply passage according to claim 6, wherein the bleed passage is open for between 2 and 4 seconds at starting of the engine and is then closed.
8. Fuel supply apparatus according to any one of claims 1 to 4, wherein the control device comprises an engine speed sensor and operates to open or close the bleed passage according to engine speed.



9. Fuel supply apparatus according to claim 8, wherein the bleed passage is opened when starting the engine and is closed when the engine reaches a predetermined speed below an idling speed.
10. Fuel supply apparatus according to any one of claims 1 to 4, wherein the control device comprises an oil pressure sensor and operates to open or close the bleed passage according to the engine oil pressure.
11. Fuel supply apparatus according to any preceding claim wherein the control device has at least one temperature sensor so that if ambient temperature and/or engine temperature is below a predetermined value the bleed passage is kept closed.
12. Fuel supply apparatus according to any preceding claim, wherein the bleed passage is openable and closeable by means of a solenoid operable valve.
13. Fuel supply apparatus according to any preceding claim, wherein the bleed passage has an orifice which controls the amount of fuel that flows therethrough.
14. Fuel supply apparatus according to any preceding claim, wherein the bleed passage returns bled fuel to a fuel reservoir.
15. Fuel supply apparatus substantially as hereinbefore described with reference to Figures 2 to 4 of the accompanying drawings.
16. An internal combustion engine having fuel supply apparatus according to any one of claims 1 to 15.
17. An internal combustion engine substantially as hereinbefore described with reference to the accompanying drawings.



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