

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 in diesel engines which use a turbocharger to pressurise and increase the density of intake air. The amount of fuel supplied to fuel injectors of the engine is controlled by a fuel pump which delivers fuel at a rate dependent on the engine speed. During wide open throttle operation the engine can accelerate to its maximum rate in a very short period of time and so does the fuel rate. However, the turbocharger is driven by the exhaust gases and hence lags the acceleration of the engine by a significant amount and cannot deliver a sufficient level of air pressure to absorb the increased fuel vapour. The result is too much fuel being present during combustion and consequent generation of black smoke or soot emitted by the vehicle exhaust.

In an attempt to eliminate acceleration smoke, turbocharged engines are often fitted with an air/fuel control device which cooperates with the fuel pump to vary the fuel flow to the engine as a direct function of the intake manifold air pressure. Thus whenever the intake air pressure is below its maximum the control device acts to reduce the amount of fuel pumped to the engine.

The above described device is effective in minimising acceleration smoke. However, the device cannot provide optimum performance throughout the engine range and overall engine performance may be affected. For example, the device may restrict the air/fuel mixture to a leaner ratio to avoid acceleration smoke but in the meantime this limits the engine power as the mix is not rich enough to produce maximum power over the full range of engine speeds.

US Patent No 4095572 describes a fuel system for a turbocharged diesel engine in which the fuel pressure is varied upon acceleration as a direct function of the engine's inlet air pressure. The air pressure signal used to control the amount of fuel is delayed by introducing a chamber of predetermined size. The

air pressure signal must first fill the chamber before having an effect on the rate of fuel supply. The effect is to introduce a delay in the increase of the fuel rate to the engine thereby minimising acceleration smoke.

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

According to the present invention there is provided fuel supply apparatus for an internal combustion engine, the apparatus comprising fuel delivery means for delivering fuel to the engine at a pressure level which increases as a direct function of increasing engine speed, and a fuel pressure damper acting between the fuel delivery means and the engine to damp the rate of increase of fuel pressure with time.

The damper is preferably pneumatic.

The fuel delivery means may supply fuel to the engine via a main fuel conduit and the damper is preferably in the form of an air-filled branch conduit connected to the main fuel conduit. The branch conduit may be a closed pipe filled at least partially with air and preferably mainly filled with air. Thus some of the fuel present in the main conduit will pass into the branch conduit and come into contact with the air. This will have the effect of damping any rapid changes in fuel pressure in the main conduit and allow the compressed air of a turbocharger to catch up with the increased fuel demand.

Preferably the branch pipe is in the form of a right-angled bend. The diameter to height ratio of the branch pipe is selected so that it cannot fill completely with fuel and is typically 30-40:1.

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

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

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

Referring 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 inlet manifold D. Fuel for a turbocharged diesel engine (not shown) is drawn from a fuel tank 1 of a vehicle by fuel pump 2 in a conventional manner (see Figure 2).

The fuel is pumped via a solenoid valve 3 and fuel line 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.

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

The fuel pump 2 has an air/fuel control device 8 which receives an air pressure signal 9 from an air intake manifold 10 of the engine and governs the amount of fuel to be pumped in response to the air pressure in the intake manifold. The greater the air pressure in the manifold the greater the amount of fuel air that is supplied by the fuel pump 2. The air/fuel control device 8 is of conventional bellows design and will not be described any further.

The exhaust gases from the engine pass over the turbine (not shown) of a turbocharger (not shown) which drives a corresponding compressor (not shown) to pressurise air in the intake manifold 10 in the conventional manner.

The fuel line 4 has an upstanding right-angled branch conduit 11 closed at an end 12 remote from the fuel line 4. The branch conduit 11 is filled mainly with air 13.

When fuel is delivered by the pump 2 to the injectors 5 via the common fuel line 6, a fraction of the fuel passes into the branch conduit 11 and communicates with the air 13 present therein.

When the vehicle operator requires the vehicle to accelerate, the increase of air pressure in the intake manifold 10 is detected by the air/fuel control device 8 and the pump 2 is operated to deliver a corresponding increase in fuel. The increase in fuel pressure in the common fuel line 6 will cause the fuel present in the branch conduit 11 to rise and compress the air 13 against the end 12. If the increase in the fuel pressure is gradual (i.e. a gradual acceleration is demanded by the vehicle operator) the compression of the air has no or negligible effect. However, when full acceleration is demanded and the rate of increase of pressure in the fuel line 4 and branch conduit 11 is significant then the fuel in the branch conduit 11 rises and compresses the air. Compression of the air has a damping effect and restricts the rate of increase of the fuel pressure. This allows the turbocharger to catch up and supply air at increased pressure to absorb the fuel vapour. The damping effect prevents too much fuel being supplied to the engine and minimises the resultant black smoke from the non-combusted fuel without affecting the steady state operation of the engine.

The branch conduit is designed to prevent fuel completely filling the interior. A height to diameter ratio of 30-40:1 is suitable for most applications. It is also important that the upstanding part of the branch conduit remains vertical

throughout a journey of a vehicle.

By acting directly on the fuel line as opposed to the air inlet (as in the system described in US 4095572) the reaction of the apparatus to the increased fuel demand is quicker and thus a faster response is achieved.

The present invention may be suitable for any form of fuel injection system where there is a lag between the air pressure and the fuel supply.

CLAIMS

1. Fuel supply apparatus for an internal combustion engine, the apparatus comprising fuel delivery means for delivering fuel to the engine at a pressure level which increases as a direct function of increasing engine speed, and a fuel pressure damper acting between the fuel delivery means and the engine to damp the rate of increase of fuel pressure with time.
2. Fuel supply apparatus according to claim 1, wherein the damper is pneumatic.
3. Fuel supply apparatus according to any preceding claim, wherein the fuel delivery means supplies fuel to the engine via a main fuel conduit and the damper is a branch conduit connected to the main fuel conduit.
4. Fuel supply apparatus according to claim 3, wherein the branch conduit is closed at an end remote from the main conduit and filled at least partially with air.
5. Fuel supply apparatus according to claim 4, wherein the branch conduit is filled mainly with air.
6. Fuel supply apparatus according to claim 4 or 5, wherein the pipe has a right-angled bend.
7. Fuel supply apparatus substantially as hereinbefore described with reference to Figure 2 of the accompanying drawings.
8. An internal combustion engine having fuel supply apparatus according to any one of the preceding claims.
9. An internal combustion engine substantially as hereinbefore described with reference to the accompanying drawings.

