FUEL INJECTION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of application Ser. No. 10/427,229, filed May 1, 2003, entitled "Fuel Injection System," which claims benefit of priority from UK application no. 0210305.9 filed May 3, 2002, UK application no. 0215487.0 filed Jul. 4, 2002, UK application no. 0225392.0 filed Oct. 31, 2002, EP application no. 03252188.2 filed Apr. 7, 2003 and EP application no. 03250957 filed Feb. 17, 2003.

FIELD OF THE INVENTION

[0002] The present invention relates to a fuel injection system for an internal combustion engine, and in particular to a fuel injection system including an accumulator volume in the form of a common rail. The fuel system of the present invention is capable of providing a range of injection pressure and injection-rate shaping characteristics. The invention also relates to a common rail fuel system including a shut off valve, and to a shut off valve for use in a fuel injection system.

BACKGROUND OF THE INVENTION

[0003] In known fuel injector designs, a nozzle control valve is provided to control movement of a fuel injector valve needle relative to a seating and, thus, to control the delivery of fuel from the injector. A so-called Electronic Unit Injector (EUI) is an example of such an injector. An Electronic Unit Injector includes a dedicated pump having a cam-driven plunger for raising fuel pressure within a pump chamber, and an injection nozzle through which fuel is injected into an associated engine cylinder. A spill valve is operable to control the pressure of the fuel within the pump chamber. When the spill valve is in an open position, the pump chamber communicates with a low pressure fuel reservoir so that fuel pressure within the pump chamber is not substantially affected by movement of the plunger and fuel is simply drawn into and displaced from the pump chamber as the plunger reciprocates. Closure of the spill valve causes pressure in the pump chamber to rise as the plunger is driven to reduce the volume of the pump chamber. Each Electronic Unit Injector has an electronically controlled nozzle control valve that is arranged to control the timing of commencement and termination of the injection of fuel into an associated engine cylinder. Typically, the engine is provided with a plurality of Electronic Unit Injectors, one for each cylinder of the engine.

[0004] Although the use of a nozzle control valve in an Electronic Unit Injector provides a capability for controlling the injection timing, and such units are capable of achieving high injection pressures, both injection pressure and injection timing are limited to some extent by the nature of the associated cam drive.

[0005] In common rail fuel injection systems, a single pump is arranged to charge an accumulator volume, or common rail, with high pressure fuel for supply to a plurality of injectors of the fuel system. As in an Electronic Unit Injector, the timing of injection is controlled by means of a nozzle control valve associated with each injector. One advantage of the common rail system is that the timing of injection of fuel at high pressure is not dependent upon a cam drive, and so fast and accurate control of the timing of injection can be achieved with the nozzle control valves. However, achieving very high injection pressure within a common rail system is problematic and the high levels to which fuel must be pressurised can cause high stresses within the pump and within the rail. The rail must therefore be provided with a relatively thick wall for pressure containment, making it heavy and bulky. Parasitic fuel losses can also be high.

[0006] It has been recognised that significant improvements in combustion quality and efficiency may be achieved by rapidly varying the injection pressure level and injection rate within an injection event. Such variations in the injection characteristics can be difficult to achieve rapidly with both Electronic Unit Injector systems and common rail systems, and the efficiency of both types of system is limited. For example, in a common rail system designed to achieve injection at a high rail pressure, it is also possible to achieve a lower injection pressure by relieving some of the high pressure fuel to a low pressure reservoir. This, however, is an inefficient use of pumping energy.

[0007] It is a feature of common rail systems that in order to terminate injection it is usually necessary to apply a high hydraulic force to the back end of the injector valve needle, and this is achieved through operation of the nozzle control valve. It has been found, however, that this results in a disruption of the fuel spray formation into the engine cylinder, and produces an unnecessary degree of smoke.

[0008] The present invention is aimed at one or more of the problems set forth above.

SUMMARY OF THE INVENTION AND ADVANTAGES

[0009] It is one aim of the present invention to provide a fuel injection system which substantially overcomes or alleviates at least one of the aforementioned limitations and disadvantages of common rail and Electronic Unit Injector fuel injection systems. It is a further aim of the invention to provide a fuel injection system having a capability for achieving injection at a range of injection pressures, and with accurate and efficient control of the injection timing and rate. It is a still further aim of the present invention to overcome or alleviate the aforementioned fuel spray degradation problem that is associated with termination of injection in common rail and Electronic Unit Injector fuel systems.

[0010] According to the present invention there is provided a fuel injection system for supplying pressurised fuel to a fuel injector, the fuel injection system comprising an accumulator volume for supplying fuel at a first injectable pressure level to the fuel injector through a fuel supply passage, pump means, in the form of a pump arrangement, for increasing the pressure of fuel supplied to the injector to a second injectable pressure level, and valve means, in the form of a valve arrangement, operable between a first position in which fuel at the first injectable pressure level is supplied to the injector and a second position in which communication between the injector and the accumulator volume is broken so as to permit fuel at the second injectable pressure to be supplied to the injector.