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(11) **EP 1 457 668 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:

15.09.2004 Bulletin 2004/38

(51) Int Cl.7: **F02M 65/00, F02M 63/02**

(21) Application number: **04005952.9**

(22) Date of filing: **12.03.2004**

(84) Designated Contracting States:

**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PL PT RO SE SI SK TR**

Designated Extension States:

AL LT LV MK

(72) Inventor: **Osaki, Masatoyo**

Kariya-city Aichi-pref. 448-8661 (JP)

(74) Representative:

Leson, Thomas Johannes Alois, Dipl.-Ing.

Tiedtke-Bühling-Kinne & Partner GbR,

TBK-Patent,

Bavariaring 4

80336 München (DE)

(30) Priority: **14.03.2003 JP 2003069811**

(71) Applicant: **Denso Corporation**

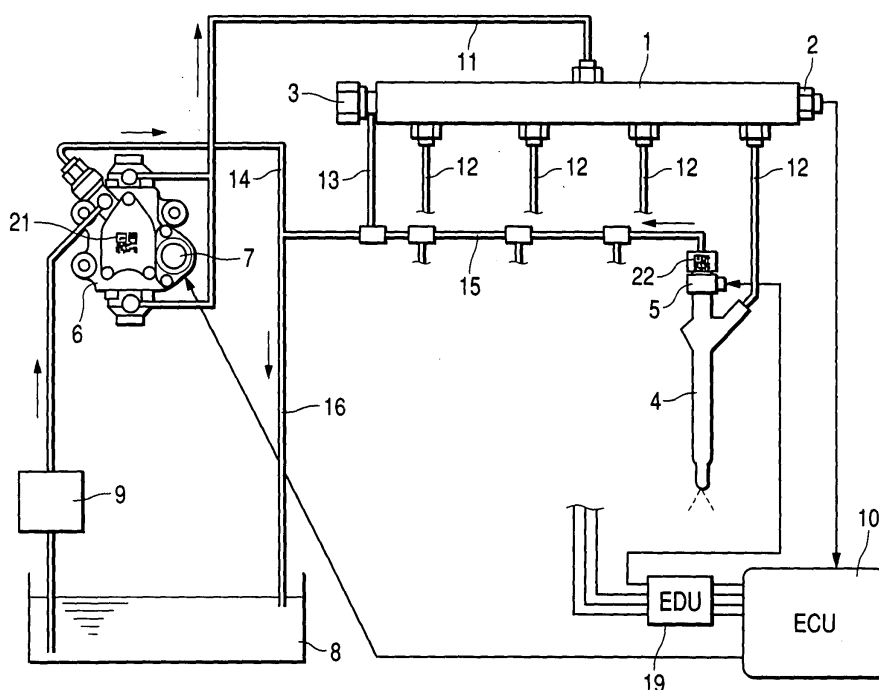
Kariya-city, Aichi-pref., 448-8661 (JP)

(54) **Fuel injection system for internal combustion engine**

(57) In a common-rail fuel injection system, measurement data on a pressure feed rate characteristic, reflecting diverse individual differences among supply pumps (6), is divided into N portions which in turn are ranked and encoded to produce ranked pressure feed rate characteristic codes (21), and one of the ranked codes (21) is distinguishably put or printed on a portion of the pump (6) confirmable or visible from the external.

Moreover, measurement data on a leak rate characteristic, reflecting diverse individual differences of injectors (4), is divided into M portions which in turn are ranked and encoded, and one of the resultant ranked leak rate characteristic codes (22) is distinguishably put or printed on a portion of the injector (4) confirmable from the external. This enables the pressurization performance of the system to be enhanced without requiring a considerable structure alteration of the pump (6).

FIG. 1



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Description

BACKGROUND OF THE INVENTION

1) Field of the Invention

[0001] The present invention relates to a fuel injection system for use in an internal combustion engine capable of combining a fuel supply pump and an injector for each rank to incorporate them into an internal combustion engine in a manner such that pressure feed rate (quantity) measurement data on the fuel supply pump and leak rate measurement data on the injector are ranked and encoded to distinguishably show the pressure feed rate ranks and the leak rate ranks at a place confirmable from the exteriors of the fuel supply pump and the injector.

2) Description of the Related Art

[0002] So far, as a fuel injection system for use in a diesel engine, there has been known a common-rail fuel injection system. This common-rail fuel injection system is designed to accumulate, in a common rail, a high-pressure fuel fed under pressure from a supply pump, which is made to pressurize a sucked fuel up to a high value, and further to inject and supply the high-pressure fuel existing in the common rail from an injector into a combustion chamber of each cylinder of an engine at a predetermined timing (for example, see Japanese Patent Laid-Open Nos. 2000-220508 and 2002-276503).

[0003] In this case, with respect to the supply pump forming a component of the common-rail fuel injection system, as one of its performance indexes there is a fuel pressure feed rate (quantity) to an operating state or operating condition of the engine and, for example, a predetermined fuel pressure feed rate (Qs) or more is required at a predetermined pump rotational speed (NP1) and at a predetermined common rail pressure (PC1).

[0004] On the other hand, also with respect to the injector forming a component of the common-rail fuel injection system, as one of its performance indexes there is a fuel leak rate (quantity) to an operating state or operating condition of the engine and, for example, a predetermined leak rate (Qi) or less is required at a predetermined pump rotational speed (NP2) and at a predetermined common rail pressure (PC2).

[0005] Meanwhile, in the common-rail fuel injection system, in the case of a shortage of the fuel pressure feed range in the supply pump or an excess of the fuel leak rate in the injector, difficulty is experienced in generating a predetermined fuel injection pressure (common rail pressure), which leads to failing to supply a predetermined fuel injection quantity (a basic injection quantity to be set in accordance with an operating state or operating condition of an internal combustion engine, for example, on the basis of an engine speed and an accelerator opening degree) into a combustion chamber of each cylinder of the internal combustion engine

through the use of an injector mounted for each cylinder of the engine. This makes it difficult to provide an engine torque corresponding to a quantity (accelerator opening degree) of an accelerator manipulation by a driver, which can cause troubles such as a shortage of output of the internal combustion engine, a detailed increase in rotation and an impairment of emission.

[0006] In addition, with respect to the conventional supply pump and injector, standard values are set to reach satisfaction even in a case in which the supply pump showing a lower limit of a characteristic standard or tolerance range in fuel pressure feed rate and the injector showing an upper limit of a characteristic standard or tolerance range in fuel leak rate are mounted on an internal combustion engine. However, if the common rail pressure is high or in the case of an internal combustion engine which requires a large injection quantity, there is a need to enhance the pressurization performance of the system. In this case, for enhancing the pressurization performance of the common-rail fuel injection system, that is, for increasing the fuel pressure feed ability of the supply pump, there is a need to carry out a considerable structure alteration of the supply pump, such as increasing the number of plungers to be built in the supply pump.

SUMMARY OF THE INVENTION

[0007] It is therefore an object of the present invention to provide a fuel injection system for an internal combustion engine capable of selecting each of a fuel supply pump and a fuel injection valve to a distinguishably shown rank before mounting it on an internal combustion engine the incorporation into the internal combustion engine to improve the system pressurization performance without requiring a considerable structure alteration of the fuel supply pump.

[0008] For this purpose, according to an aspect of the present invention, measurement data on a pressure feed rate characteristic or injection pressure characteristic reflecting an individual difference of a fuel supply pump and measurement data on a leak rate characteristic, injection quantity characteristic or an injection timing characteristic reflecting an individual difference of a fuel injection valve are ranked and encoded, and the pump characteristic codes and the injection valve characteristic codes are distinguishably shown at a place confirmable from the exteriors of the fuel supply pump and the fuel injection valve so that, at the incorporation thereof into an internal combustion engine, each of the fuel supply pump distinguishably showing the pump characteristic code and the fuel injection valve distinguishably showing the injection valve characteristic code is selected to a distinguishable rank to be mounted on the internal combustion engine.

[0009] Thus, although there is a need to enhance the pressurization performance of the system when the fuel injection pressure (for example, common rail pressure)

is high or in the case of an internal combustion engine which requires a large injection quantity, since, for enhancing the pressurization performance of the fuel injection system for use in the internal combustion engine, for example, a fuel supply pump ranking satisfactory in pressure feed rate characteristic or injection pressure characteristic and a fuel injection valve ranking satisfactory in leak rate characteristic, injection quantity characteristic or injection timing characteristic are mounted on the internal combustion engine in a state combined with each other, the enhancement of the pressurization performance of the internal combustion engine fuel injection system becomes feasible without requiring a considerable structure alteration of the fuel supply pump.

[0010] In this construction, it is also appropriate that a characteristic standard or tolerance range of the fuel supply pump is divided into two or more to encode measurement data on ranked pressure feed rate characteristics or injection pressure characteristics so that a two-dimensional code printed at a place of a surface of the fuel supply pump easily confirmable from the external is used as the pump characteristic code. Among the two-dimensional codes usable, there are binary digit codes, decimal digit codes, sexadecimal digit codes, bar codes, QR (quick response) codes and others, which are easily readable through the use of visual observation, image processing, a bar code readers or the like. Moreover, it is also acceptable to use the number of stars or dots, alphabets or other marks which are given in consideration of the quality evaluation (rank) of a fuel injection pump product.

[0011] In addition, it is also appropriate that a characteristic standard or tolerance range of the fuel injection valve is divided into two or more to encode measurement data on ranked leak rate characteristics, injection quantity characteristics or injection timing characteristics so that a two-dimensional code printed at a place of a surface of the fuel injection valve easily confirmable from the external is used as the injection valve characteristic code. Among the two-dimensional codes usable, there are binary digit codes, decimal digit codes, sexadecimal digit codes, bar codes, QR (quick response) codes and others, which are easily readable through the use of visual observation, image processing, a bar code readers or the like. Moreover, it is also acceptable to use the number of stars or dots, alphabets or other marks which are given in consideration of the quality evaluation (rank) of a fuel injection valve product.

[0012] Still additionally, according to a further aspect of the present invention, for example, as a fuel injection system for a diesel engine, it is possible to employ a common-rail fuel injection system in which a high-pressure fuel fed under pressure from the fuel supply pump is accumulated in a common rail and the fuel injection valve is opened at a predetermined timing to inject and supply the high-pressure fuel in the common rail through the fuel injection valve into each cylinder of the internal combustion engine.

[0013] Yet additionally, according to a further aspect of the present invention, it is also appropriate that an valve-opening timing and a valve-opening time of a nozzle needle accommodated in a nozzle body to be slidable to open and close an injection hole are adjusted in accordance with a drive signal to be applied from an engine control unit to needle drive means of the fuel injection valve. In this case, it is also appropriate that, as the needle drive means, a solenoid valve (electromagnetic actuator) is used which drives the nozzle needle in a valve-opening direction against a biasing force of needle biasing means in a manner such that a high-pressure fuel supplied into a pressure control chamber, which implements operation control of the nozzle needle, i.e., back pressure control on a command piston interlocked with the nozzle needle, overflows through a fuel leak passage toward a low-pressure side of a fuel system.

[0014] Moreover, according to a further aspect of the present invention, it is also appropriate that an opening degree of a fuel suction passage from a feed pump to a pressurizing chamber is adjusted in accordance with a drive signal to be applied from the engine control unit to a suction control (metering) valve of the fuel supply pump to change the fuel pressure feed rate from the pressurizing chamber of the fuel supply pump to the common rail for controlling the fuel injection pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Other objects and features of the present invention will become more readily apparent from the following detailed description of the preferred embodiments taken in conjunction with the accompanying drawings in which:

FIG. 1 schematically shows the entire construction of a common-rail fuel injection system according to an embodiment of the present invention;

FIG. 2 illustratively shows measurement data on a pressure feed rate characteristic of a supply pump according to the embodiment of the present invention; and

FIG. 3 illustratively shows measurement data on a leak rate characteristic of an injector according to the embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] An embodiment of the present invention will be described hereinbelow with reference to the drawings. FIGS. 1 to 3 are illustrations of an embodiment of the present invention, and FIG. 1 is an illustration of the entire construction of a common-rail fuel injection system.

[0017] The fuel injection system for use in an internal combustion engine shown in FIG. 1 is a common-rail fuel injection system (accumulation fuel injection de-

vice) known as a fuel injection system for an internal combustion engine (which will hereinafter be referred to as an "engine") such as a multi-cylinder diesel engine and is designed to inject and supply a high-pressure fuel from a plurality of (four in this example) injectors 4 branching off from a common rail 1 into the combustion chambers of the respective cylinders at predetermined timings.

[0018] This common-rail fuel injection system is made up of the common rail 1 for accumulating a high-pressure fuel corresponding to a fuel injection pressure, the plurality of injectors (fuel injection valves) 4 for injecting the fuel into the combustion chambers of the engine cylinders, a fuel supply pump (supply pump) 6 for pressurizing the fuel sucked into a pressurizing chamber up to a high pressure value, and an engine control unit (which will hereinafter be referred to as an "ECU") 10 for electronically controlling the actuators for the plurality of injectors 4 and the actuator for the supply pump 6. In FIG. 1, only the injector 4 corresponding to one cylinder of a four-cylinder engine is illustrated and the other cylinders are omitted from the illustration.

[0019] In this embodiment, the common rail 1 is required to accumulate a high-pressure fuel corresponding to a fuel injection pressure at all times and, hence, the high-pressure fuel is fed under pressure from the supply pump 6 through a high-pressure fuel passage (high-pressure pipe) 11 thereto. Moreover, at one end portion (right-side end portion in the illustration) of the common rail 1 in its longitudinal direction (right and left direction in the illustration), there is set a fuel pressure sensor (fuel pressure detecting means) 2 for detecting a common rail pressure (PC) which will be mentioned later. Still moreover, at the other end portion (left-side end portion in the illustration) of the common rail 1 in its longitudinal direction (right and left direction in the illustration), there is set a normally closed pressure reducing valve 3 for opening and closing a fuel refluxing passage (low-pressure pipe) 13 coupled to fuel refluxing passages (low-pressure pipes) 15 and 16 communicating with a fuel tank (low-pressure side of the fuel system) 8.

[0020] The pressure reducing valve is a solenoid valve (electromagnetic flow rate control valve made to control the quantity of a fuel to be refluxed to a low-pressure side of the fuel system by changing the valve opening degree, or an electromagnetically opened and closed valve made to take an open condition when energized and to take a closed condition when the energizing comes to a stop) superior in pressure decreasing performance, that is, pressure-reducing the common rail pressure (PC) quickly from a high-pressure side to a low-pressure side, for example, at deceleration or engine stop when electronically controlled in accordance with a pressure reducing valve drive signal from the ECU 10. Incidentally, it is also possible that, in place of the pressure reducing valve 3, a pressure limiter (pressure safety valve) is provided which falls into an open condition when the fuel pressure in the common rail 1

exceeds a limit set pressure for controlling the fuel pressure in the common rail 1 to below the limit set pressure.

[0021] The injector 4 mounted for each cylinder of the engine is an electromagnetic fuel injection valve connected to a downstream end portion of each of a plurality of high-pressure passages (high-pressure pipes) 12 branching off from the common rail 1, which is composed of a nozzle for carrying out the fuel injection into the corresponding cylinder of the engine, a nozzle holder connected to an upward side of this nozzle (in the illustration), a needle drive means (electromagnetic actuator; which will be referred to hereinafter as a solenoid valve) 5 for driving a valve body (nozzle needle; not shown), accommodated in the nozzle, in a valve opening direction, and a needle biasing means (not shown), such as a spring, for biasing the nozzle needle into a valve closing direction. The nozzle includes a nozzle body having an injection hole made therein and a nozzle needle accommodated in the nozzle body to be slidable for opening and closing the injection hole.

[0022] In the nozzle holder, there are formed a fuel supply passage (not shown) for supplying a high-pressure fuel from a coupling portion, made to accomplish the connection to the downstream end portion of each high-pressure pipe 12 branching off from the common rail 1, to a fuel sump made around a seat portion of the nozzle needle in the nozzle, and another fuel supply passage (not shown) for supplying the high-pressure fuel, for example, through an orifice, from the aforesaid coupling portion to a back pressure control chamber (pressure control chamber; not shown) made to control the back pressure of a command piston connected to the nozzle needle.

[0023] The fuel injection from each of these injectors 4 into the interior of the combustion chamber of each cylinder is electronically controlled through the energizing on a solenoid coil of the solenoid valve 5 for controlling the fuel pressure in the back pressure control chamber and the energizing stop (ON/OFF). That is, while the solenoid valve 5 of the injector 4 for each cylinder is energized so that the nozzle needle is placed into a valve opening condition, the high-pressure fuel accumulated in the common rail 1 is injected/supplied into the combustion chamber of each cylinder of the engine. In this case, the leak fuel overflowing from each injector 4 to the low-pressure side of the fuel system or the discharge fuel (return fuel) from the back pressure control chamber returns from a fuel reflux passage (fuel leak passage) 15 through a fuel reflux passage (fuel leak passage) 16 to the low-pressure side (fuel tank 8) of the fuel system.

[0024] The supply pump 6 is made up of a well-known feed pump (low-pressure supply pump; not shown) for pumping up a low-pressure fuel from the fuel tank 8 through a fuel filter 9 by means of the rotation of its pump drive shaft stemming from the rotation of a crank shaft of the engine, a cam (not shown) rotationally driven by the pump drive shaft, a plurality of (two in this example) plungers (not shown) driven by this cam to reciprocate

between a top dead center and a bottom dead center, a plurality of pressurizing chambers (plunger chambers; not shown) each for pressurizing, up to a high pressure value, the low-pressure fuel sucked when the corresponding plunger reciprocates in the cylinder, a plurality of fuel suction passages (not shown) for sucking the low-pressure fuel from the feed pump into the plurality of pressurizing chambers, and a plurality of fuel pressure feed passages having a high-pressure pipe 11 from the plurality of pressurizing chambers for pressurizing, up to a high pressure value, the low-pressure fuel sucked from the fuel tank 8 through the fuel filter 9 and a pump chamber into the pressurizing chambers and further for pressure-feeding the high-pressure fuel from the pressurizing chambers through discharge openings and the high-pressure pipe 11 into the common rail 1.

[0025] In each of the plurality of fuel suction passages, there is placed each of a plurality of suction check valves (not shown) for preventing the back flow. Moreover, in each of the plurality of fuel pressure feed passages, there is provided each of a plurality of discharge valves (high-pressure check valves; not shown) each placed into an open condition when the fuel pressure in each of the plurality of pressurizing chambers exceeds a predetermined value. Still moreover, in the supply pump 6, there is provided a leak port which is for preventing the fuel temperature in the interior of the supply pump 6 from reaching a high temperature, with the leak fuel (return fuel) from the supply pump 6 being returned from the fuel reflux passage 14 through the fuel reflux passage 16 to the low-pressure side (fuel tank 8) of the fuel system.

[0026] In addition, in the middle of a fuel passage (not shown) making a communication between the exist portion of the feed pump of the supply pump 6 and the plurality of fuel suction passages or in the middle of a fuel suction passage for feeding the fuel from the feed pump of the supply pump 6 into the pressurizing chamber, a suction control (metering) valve (SCV) 7 is set which adjusts the valve opening degree (opening degree of a valve hole or lift quantity of a valve body) in the fuel passage or in the fuel suction passage to change the fuel discharge quantity (fuel pressure feed quantity) from the supply pump 6 to the common rail 1.

[0027] The suction control valve 7 is an electromagnetic flow rate control valve made to control the quantity of the fuel suction sucked from the feed pump of the supply pump 6 into the pressurizing chamber, and composed of a valve body (valve; not shown) for adjusting the opening degree of the fuel passage or the fuel suction passage, a solenoid coil (not shown) for driving the valve in a valve closing direction in accordance with a pump drive signal, a valve biasing means (not shown) such as a spring for biasing the valve in a valve opening direction, and others. More specifically, the suction control valve 7 is a normally open type solenoid valve (pump flow rate control valve) made such that its valve opening degree reaches a fully open state when the energizing

on the solenoid coil comes to a stop.

[0028] The suction control valve 7 is designed to adjust the suction quantity of the fuel to be sucked into the pressurizing chamber of the supply pump 6 in proportion to the magnitude of the value of a pump drive current applied, for example, through a pump drive circuit to the solenoid coil by means of being electronically controlled by a pump drive signal from the ECU 10 for changing the fuel discharge quantity (fuel pressure feed quantity) to be discharged from the supply pump 6, thereby controlling the common rail pressure corresponding to the injection pressure of the fuel to be injected from each injector 4 into each cylinder of the engine.

[0029] The ECU 10 comprises a microcomputer with a well-known arrangement, which is equipped with the functions of a CPU for carrying out the control processing and arithmetic operations, a storage unit (memory: ROM, RAM) for retaining various programs and data, an input circuit, an output circuit, a power supply circuit, a pump drive circuit and others. Moreover, when an engine key is inserted into a key cylinder and turned up to an IG position to make an ignition switch (not shown) turn on (IG ON), on the basis of a control program stored in the memory, the ECU 10 is made to electronically control, for example, the pressure reducing valve 3, the solenoid valves 5 of the plurality of injectors 4 and the suction control valve 7 of the supply pump 6. Incidentally, in response to the turning-off of the ignition switch (IG OFF), the ECU 10 is made such that the aforesaid control based on the control program stored in the memory comes compulsively to an end.

[0030] In this arrangement, sensor signals from various sensors are A/D-converted through an A/D converter before inputted to the microcomputer built in the ECU 10. The microcomputer is connected to operation condition detecting means for detecting an operation condition or operation state of the engine, that is, it is connected to an engine speed sensor (not shown) for detecting an engine rotational speed (equally referred to as an engine speed; NE), an accelerator opening-degree sensor (not shown) for detecting the accelerator opening degree (ACCP), a cooling water temperature sensor (not shown) for detecting an engine cooling water temperature (THW), a fuel temperature sensor (not shown) for detecting a pump suction side fuel temperature (THF) of the fuel sucked into the supply pump 6, and others.

[0031] In addition, the ECU 10 includes an injection quantity control means which calculates an optimum fuel injection quantity corresponding to an engine operation state or operation condition and drives the solenoid valve 5 of the injector 4 for each cylinder through an injector drive circuit (EDU) 19. This injection quantity control means includes a basic injection quantity determining means for calculating an optimum basic injection quantity (Q) as a function of an engine speed (NE) and an accelerator opening degree (ACCP), a command injection quantity determining means for calculating a

command injection quantity (QFIN) by adding, to the basic injection quantity (Q), an injection quantity correction value determined in consideration of an engine cooling water temperature (THW), a pump suction side fuel temperature (THF) and the like, an injection timing determining means for calculating a command injection timing (T) on the basis of the engine speed (NE) and the command injection quantity (QFIN), an injection time determining means for calculating an energizing time (command injection time, injector injection pulse time, injection pulse width) on the solenoid valve 5 of the injector 4 on the basis of a common rail pressure (PC) and the command injection quantity (QFIN), and an injector drive means for applying a pulse-like injector drive current (injector injection pulse) through the injector drive circuit (EDU) 19 to the solenoid valve 5 of the injector 4 for each cylinder.

[0032] Still additionally, the ECU 10 includes a fuel discharge quantity control means (fuel pressure feed rate control means, fuel pressure control means, injection pressure control means) made to calculate an optimum common rail pressure corresponding to an engine operation state or operation condition for driving the suction control valve 7 of the supply pump 6 through the pump drive circuit. This fuel discharge quantity control means calculates a target common rail pressure (PFIN) as a function of the engine speed (NE) and the command injection quantity (QFIN) and, for achieving this target common rail pressure (PFIN), adjusts the pump drive signal (SCV drive current) to the suction control valve 7 of the supply pump 6 to change the fuel discharge quantity (fuel pressure feed rate) to be discharged from the supply pump 6, thereby controlling the fuel pressure (common rail pressure) in the interior of the common rail 1.

[0033] More preferably, a fuel pressure sensor 2 is attached to the common rail 1 and the pump drive signal (SCV drive current) to the solenoid coil of the suction control valve 7 of the supply pump 6 is feedback-controlled so that the common rail pressure (PC) detected by this fuel pressure sensor 2 agrees generally with the target common rail pressure (PFIN).

[0034] In this connection, it is preferable that the control of the SCV drive current to the solenoid coil of the suction control valve 7 is executed by means of duty control. That is, the high-accuracy digital control becomes feasible through the employment of the duty control whereby the ratio (energizing time ratio, duty ratio) of ON/OFF of the pump drive signal per unit time is adjusted on the basis of a pressure deviation (difference) (ΔP) between the common rail pressure (PC) and the target common rail pressure (PFIN) to change the valve opening degree (opening degree of a valve hole or lift quantity of a valve body) of the suction control valve 7 of the supply pump 6.

(Features of Embodiment)

[0035] Referring to FIGs. 1 to 3, a description will be given hereinbelow of features of the common rail fuel injection system according to this embodiment. FIG. 2 is an illustration of flow level data (pressure feed rate characteristic measurement data) on a fuel pressure feed rate of a supply pump, and FIG. 3 is an illustration of flow level data rate (leak rate characteristic measurement data) on a fuel leak from an injector.

[0036] First, FIG. 2 is an illustration of a normal distribution (Gaussian distribution) showing an example of distribution of each fuel pressure feed rate of all products (supply pumps 6) with respect to a predetermined SCV drive current according to the individual examination of the fuel pressure feed rate of each supply pump 6 in a case in which the predetermined SCV drive current (constant current value) is applied to a solenoid coil of a suction control valve 7. Moreover, FIG. 2 shows an example in which a characteristic standard (tolerance range) of a supply pump 6 which can be put as a product on the market is divided into N : C1, C2, ..., Cn-1, Cn, in a direction from the lower limit of the pressure feed rate characteristic standard to an increase of the fuel pressure feed rate (pressurization performance enhancing side).

[0037] FIG. 3 is an illustration of a normal distribution (Gaussian distribution) showing an example of distribution of each injector leak rate of all products (injectors 4) with respect to a predetermined injector drive current according to the individual examination of the fuel leak rate (injector leak rate) from the injector 4 in a case in which the predetermined injector drive current (injector injection pulse with a constant pulse width) is applied to a solenoid coil of the solenoid valve 5 of the injector 4. Moreover; FIG. 3 shows an example in which a characteristic standard (tolerance range) of an injector 4 which can be put as a product on the market is divided into M : C1, C2, ..., Cm-1, Cm, in a direction from the upper limit of the leak rate characteristic standard to an injector leak rate decreasing side (pressurization performance enhancing side).

[0038] In this embodiment, the flow level data of the supply pump 6, i.e., the pressure feed rate characteristic measurement data, reflecting diverse individual differences among the supply pumps 6, is divided into N which in turn are ranked and encoded, and one of the ranked pump characteristic codes (pressure feed rate characteristic codes) 21 is distinguishably put (printed) at a surface (at a place confirmable or visible from the external) of the supply pump 6. As the code printing portion of the supply pump 6, for example, as shown in FIG. 1, the aforesaid pressure feed rate characteristic code 21 is printed at a central portion of an outer wall surface of a pump housing of the supply pump 6 (for example, in the vicinity of a place where a pump individual number is printed for identifying the individual supply pump 6). As an example of printing on the supply pump 6, it can

be considered to use the number of stars or dots, alphabets or other marks, which are to be determined in consideration of the quality evaluation (rank) of a supply pump product, or two-dimensional codes such as binary digit codes, decimal digit codes, hexadecimal digit codes, bar codes, QR (quick response) codes.

[0039] In addition, the leak rate characteristic measurement data, reflecting diverse individual differences among the injectors 4, is divided into M which in turn are ranked and encoded, and one of the ranked injection valve characteristic codes (leak rate characteristic codes) 22 is distinguishably put (printed) at a surface (at a place confirmable or visible from the external) of the injector 4. As the code printing portion of the injector 4, for example, as shown in FIG. 1, the aforesaid leak rate characteristic code 22 is printed at a central portion of an outer wall surface of a valve body having a leak port of the solenoid valve 5 of the injector 4. As an example of printing on the injector 4, as well as the supply pump 6, it can be considered to use the number of stars or dots, alphabets or other marks, which are to be determined in consideration of the quality evaluation (rank) of an injector product, or two-dimensional codes such as binary digit codes, decimal digit codes, hexadecimal digit codes, bar codes, QR (quick response) codes.

[0040] Therefore, in an engine factory in which engine parts or engine accessories are built in an engine body to produce an engine product to be mounted on a vehicle body, the aforesaid two-dimensional codes can be read through the use of visual observation, image processing, a bar code readers or the like so that an injector 4 and a supply pump 6 are selected according to the pressure feed rank of the pressure feed rate characteristic code 21 and the leak rate rank of the leak rate characteristic code 22, which are distinguishably indicated, and mounted in an engine. That is, the leak rate of the injector 4 can be selected with respect to the rank of the discharge rate characteristic of the supply pump 6 so that the injector 4 and the supply pump 6 are mounted in the same engine, or conversely, the rank of the discharge rate characteristic can be selected to the leak rate rank of the injector 4 so that they are mounted in the same engine.

[0041] Alternatively, they can also be selectively combined to a required performance of an engine and mounted in the engine. For example, in a case in which the common rail pressure is high or in the case of an internal combustion engine which requires a large injection quantity, there is a need to enhance the pressurization performance of the common rail fuel injection system. In this case, for enhancing the pressurization performance of the common-rail fuel injection system, if a supply pump 6 having a fuel pressure feed rate quality evaluation (rank) of Cn in FIG. 2 and an injector (at least one or more injectors) 4 having a fuel leak rate (injector leak rate) quality evaluation (rank) of Cm in FIG. 3 are mounted in the same engine requiring the enhancement of the pressurization performance, then this enables a

conventional supply pump structure to cope with an engine with a large displacement without carrying out a considerable structure alteration, such as increasing the number of plungers for the purpose of increasing the pressure feed ability of the supply pump 6. Moreover, this enables the conventional supply pump structure to handle a higher-pressure common rail pressure.

(Other Embodiments)

[0042] Although in this embodiment one of the pump characteristic codes (pressure feed rate characteristic codes) 21 obtained by N-dividing, ranking and encoding the measurement data on the pressure feed rate characteristic (discharge rate characteristic, suction rate characteristic) reflecting the diverse individual differences among the supply pumps 6 is distinguishably put (printed) on a surface of the supply pump 6 to be identifiable from the exterior of the supply pump 6, it is also appropriate that one of the pump characteristic codes (for example, injection pressure characteristic codes) obtained by two-or-more-dividing, ranking and encoding the measurement data on the injection pressure characteristic reflecting the diverse individual differences among the supply pumps 6 is distinguishably put (printed) on a surface of the supply pump 6 to be identifiable from the exterior of the supply pump 6.

[0043] In addition, although in this embodiment one of the injection valve characteristic codes (leak rate characteristic codes) 22 obtained by M-dividing, ranking and encoding the measurement data on the leak rate characteristic reflecting the diverse individual differences among the injectors 4 is distinguishably put on a surface of the injector 4 to be identifiable from the exterior of the injector 4, it is also appropriate that one of the injection valve characteristic codes (for example, injection quantity characteristic codes) obtained by two-or-more-dividing, ranking and encoding the measurement data on the injection quantity characteristic (injection time characteristic) or the injection timing characteristic reflecting the diverse individual differences among the injectors 4 is distinguishably put (printed) on a surface of the injector 4 to be identifiable from the exterior of the injector 4. In this case, the measurement data on the injection quantity characteristic (injection time characteristic) is obtainable by measuring the fuel injection quantity to be actually injected into the combustion chamber of each cylinder of the engine when an injector drive current with a predetermined pulse width is applied to the solenoid coil of the solenoid valve 5 of the injector 4. Moreover, the measurement data on the injection timing characteristic is attainable by measuring the timing (for example, a variation of the common rail pressure or the like is recognizable) at which the nozzle needle actually starts to lift after an injector drive current is applied to the solenoid coil of the solenoid valve 5 of the injector 4.

[0044] It should be understood that the present inven-

tion is not limited to the above-described embodiments, and that it is intended to cover all changes and modifications of the embodiments of the invention herein which do not constitute departures from the spirit and scope of the invention.

[0045] In a common-rail fuel injection system, measurement data on a pressure feed rate characteristic, reflecting diverse individual differences among supply pumps (6), is divided into N portions which in turn are ranked and encoded to produce ranked pressure feed rate characteristic codes (21), and one of the ranked codes (21) is distinguishably put or printed on a portion of the pump (6) confirmable or visible from the external. Moreover, measurement data on a leak rate characteristic, reflecting diverse individual differences of injectors (4), is divided into M portions which in turn are ranked and encoded, and one of the resultant ranked leak rate characteristic codes (22) is distinguishably put or printed on a portion of the injector (4) confirmable from the external. This enables the pressurization performance of the system to be enhanced without requiring a considerable structure alteration of the pump (6).

Claims

1. A fuel injection system for an internal combustion engine, comprising:

a fuel supply pump (6) for pressurizing a fuel up to a high pressure value; and
a fuel injection valve (4) for injecting the high-pressure fuel discharged from the fuel supply pump (6) into each of cylinders of said internal combustion engine,

characterised in that measurement data on a pressure feed rate characteristic and an injection pressure characteristic, reflecting an individual difference of said fuel supply pump (6), are ranked and encoded to produce pump characteristic codes (21) and one of the produced pump characteristic codes (21) is distinguishably put on a surface of said fuel supply pump (6) to be confirmable from the external,

measurement data on a leak rate characteristic, an injection quantity characteristic or an injection timing characteristic, reflecting an individual difference of said fuel injection valve (4), are ranked and encoded to produce injection valve characteristic codes (22), and one of the produced injection valve characteristic codes (22) is distinguishably put on a surface of said fuel injection valve (4) to be confirmable from the external, and

for incorporation into said internal combustion engine, each of said fuel supply pump (6) distinguishably showing said pump characteristic code (21) and said fuel injection valve (4) distinguishably

showing said injection valve characteristic code (22) is selected according to a distinguishable rank to be mounted on said internal combustion engine.

2. The system according to claim 1, **characterised in that**, in a state where a characteristic standard or tolerance range of said fuel supply pump (6) is divided into two or more, said measurement data on the ranked pressure feed rate characteristics or injection pressure characteristics are encoded for said pump characteristic codes (21), and each of said pump characteristic codes (21) is a two-dimensional code printed at a place of a surface of said fuel supply pump (6) easily confirmable from the external.

3. The system according to claim 1, **characterised in that**, in a state where a characteristic standard or tolerance range of said fuel injection valve (4) is divided into two or more, said measurement data on the ranked leak rate characteristics, injection quantity characteristics or injection timing characteristics are encoded for said injection valve characteristic codes (22), and each of said injection valve characteristic codes (22) is a two-dimensional code printed at a place of a surface of said fuel injection valve (4) easily confirmable from the external.

4. The system according to claim 1, **characterised by** further comprising:

a common rail (1) for accumulating a high-pressure fuel fed under pressure from said fuel supply pump (6); and
a fuel leak passage for returning a fuel, overflowing at least said fuel injection valve (4), to a low-pressure side of a fuel system, said high-pressure fuel accumulated in said common rail (1) being injected and supplied through said fuel injection valve (4) into said cylinder of said internal combustion engine.

5. The system according to claim 4, **characterised in that** said fuel injection valve (4) includes:

a nozzle body having an injection hole made therein;
a nozzle needle accommodated in said nozzle body to be slidable to open and close said injection hole;
needle drive means for driving said nozzle needle in a valve opening direction; and
needle biasing means for biasing said nozzle needle in a valve closing direction,
said needle drive means adjusting a valve-opening timing and a valve-opening time of said nozzle needle in accordance with a drive signal to be applied from an engine control unit (10)

thereto for controlling a fuel injection timing and a fuel injection quantity when said fuel is injected into said cylinder of said internal combustion engine.

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6. The system according to claim 4, **characterised in that** said fuel supply pump (6) includes:

a feed pump rotationally driven by said internal combustion engine for pumping up the fuel from said low-pressure side of said fuel system; a pump element for pressurizing, up to a high pressure value, the fuel sucked into a pressurizing chamber by said feed pump; and a suction control valve (7) for adjusting an opening degree of a fuel suction passage from said feed pump to said pressurizing chamber, said suction control valve (7) adjusting the opening degree of said fuel suction passage in accordance with a drive signal to be applied from an engine control unit (10) thereto to change a fuel pressure feed rate from said pressurizing chamber to said common rail (1) for controlling an injection pressure of the fuel.

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FIG. 1

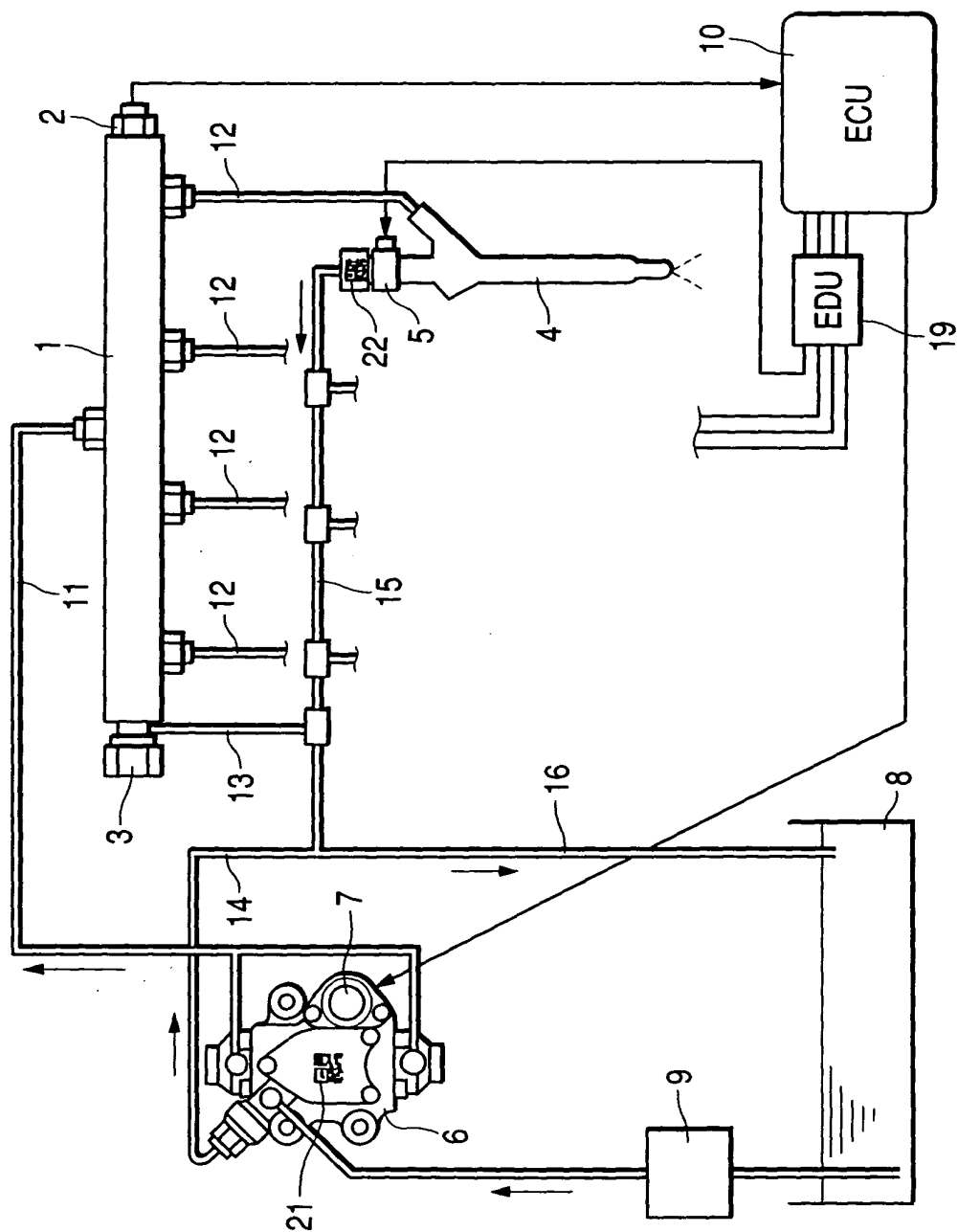


FIG. 2

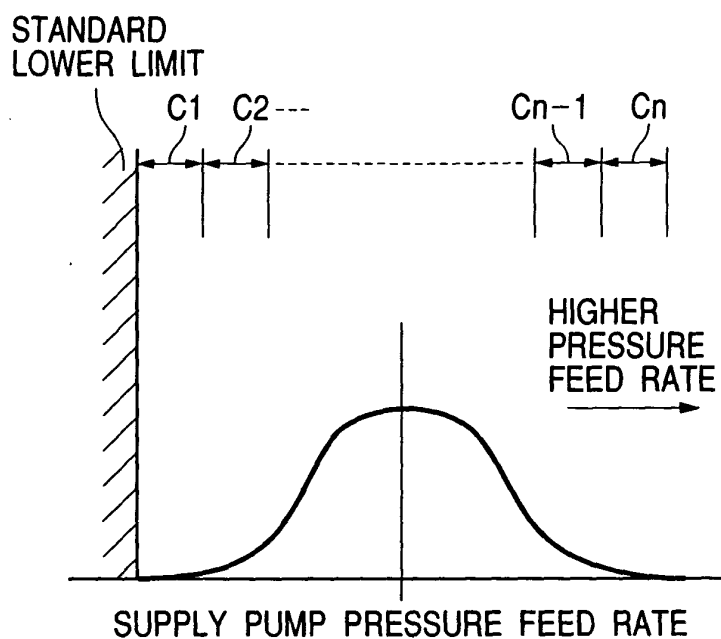


FIG. 3

