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(54) **Malfunction diagnostic device and malfunction diagnostic method for fuel system**

Fehlfunktionsdiagnosevorrichtung und Fehlfunktionsdiagnoseverfahren für Kraftstoffanlage

Dispositif de diagnostic de défaillances et procédé de diagnostic de défaillances pour système de carburant

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a malfunction diagnostic device and a malfunction diagnostic method for a fuel system, and more particularly to a malfunction diagnostic device and a malfunction diagnostic method that control a fuel system for diagnosing whether a pressure reducing valve, which reduces the pressure of fuel, malfunctions or operates normally.

2. Description of the Related Art

[0002] Diesel engines in which high-pressure fuel stored in a common rail is injected from an injector have been put to practical use. The pressure of fuel inside the common rail is controlled to obtain a target pressure that is set correspondingly to the operation state of the engine and vehicle.

[0003] However, where the target pressure decreases, the pressure of fuel inside the common rail can increase with respect to the target pressure. Accordingly a pressure reducing valve is provided in the common rail in order to decrease rapidly the pressure of fuel in the common rail. Where the pressure reducing valve is controlled to open, the pressure in the common rail decreases rapidly. As a result, the difference between the pressure of fuel inside the common rail and the target pressure can be reduced.

[0004] Meanwhile, where the pressure reducing valve malfunctions, if the pressure reducing valve is open, the pressure of fuel inside the common rail cannot be reduced. Therefore, in order to determine whether the pressure reducing valve has to be repaired, it is necessary to diagnose whether the pressure reducing valve malfunctions.

[0005] Japanese Patent Application Publication No. 2007-100624 (JP-A-2007-100624) discloses a fuel injection control device that diagnoses whether a pressure reducing valve malfunctions on the basis of the behavior of fuel pressure in a pressure accumulation chamber (common rail) that is detected when the pressure reducing valve is operated.

[0006] Furthermore, where a sensor that detects the pressure of fuel inside the common rail malfunctions, the behavior of pressure is detected erroneously and whether the pressure reducing valve malfunctions can be diagnosed erroneously. For this reason, the fuel injection control device described in JP-A-2007-100624 determines whether the pressure reducing valve malfunctions in a case in which the sensor that detects the pressure does not malfunction.

[0007] However, conditions that are unsuitable for malfunction diagnostic of the pressure reducing valve can be also realized even when the sensor that detects the pressure does not malfunction. In a case where the malfunction diagnostic of the pressure reducing valve is executed under conditions unsuitable for malfunction diagnostic of the pressure reducing valve, the engine or pressure reducing valve are adversely affected.

[0008] Furthermore, in the above-described case, the pressure reducing valve can be erroneously diagnosed as malfunctioning.

[0009] For example, the pressure of fuel inside the common rail can also fluctuate when the injector and fuel pump malfunction. Therefore, it is difficult to specify which of malfunctions of the injector, fuel pump, or pressure reducing valve causes fluctuations of fuel pressure in the common rail occurring when the pressure reducing valve is operated. Therefore, whether the pressure reducing valve malfunctions can be diagnosed erroneously.

[0010] Document DE 10 2006 000 117 A1 discloses a fuel-injection apparatus for an internal combustion engine of a motor vehicle. The fuel-injection apparatus has a valve closing abnormality determination unit that judges an irregularity generated to a valve closing operation of a pressure reduction valve. A maximum miss pressure reduction amount estimation unit performs an approximation by assuming the maximum miss pressure reduction amount that shows the maximum decent amount of the real pressure resulting from the valve opening of the pressure reduction valve. The pressure reduction-valve lowers and increases the real pressure of the fuel accumulated pressure by the common rail by the valve opening.

SUMMARY OF THE INVENTION

[0011] It is an object of the present invention to provide a malfunction diagnostic device and a malfunction diagnostic method for a fuel system that make it possible to determine with good accuracy whether the pressure reducing valve malfunctions.

[0012] This object is achieved by a malfunction diagnostic device according to claim 1 and a malfunction diagnostic method according to claim 13. Advantageous further developments are as set forth in the dependent claims.

[0013] The first aspect of the invention relates to a malfunction diagnostic device for a fuel system provided with a fuel injection valve that injects a fuel, a storage unit that stores the fuel to be supplied to the fuel injection valve, a fuel pump that supplies the fuel to the storage unit, and a pressure reducing valve that reduces a pressure of the fuel inside the storage unit in an open state. The malfunction diagnostic device includes detection means for detecting the pressure of fuel inside the storage unit, and execution means for executing a malfunction diagnostic mode in which the fuel injection valve is controlled so as to restrict the injection of fuel and the pressure reducing valve is controlled from a closed state to an open state in a state in which the rotation speed of the fuel pump

has decreased to a threshold value.

[0014] With such a configuration, it is possible to detect the pressure of fuel in a state in which the fuel injection valve and fuel pump produce little effect on the pressure of fuel. Where the pressure of fuel in this state decreases, the pressure of fuel can be said to be decreased by normal opening of the pressure reducing valve. As a result, the operator can diagnose whether the pressure reducing valve malfunctions on the basis of fuel pressure behavior affected by the operation of the pressure reducing valve. Therefore, a malfunction diagnostic device for a fuel system can be provided that can determine with good accuracy whether the pressure reducing valve malfunctions.

[0015] The malfunction diagnostic device according to the first aspect may further include determination means for determining whether a condition relating to at least one from among an increase in the pressure of fuel inside the storage unit, a decrease in the pressure of fuel to be detected inside the storage unit, and drive of the pressure reducing valve is fulfilled, and restriction means for restricting the control performed to drive the pressure reducing valve when the condition is determined to have been fulfilled.

[0016] The second aspect of the invention relates to a malfunction diagnostic device for a fuel system provided with a fuel injection valve that injects a fuel, a storage unit that stores the fuel to be supplied to the fuel injection valve, a fuel pump that supplies the fuel to the storage unit, and a pressure reducing valve that reduces a pressure of the fuel inside the storage unit in an open state. This malfunction diagnostic device includes a detection means for detecting the pressure of fuel inside the storage unit; execution means for executing a malfunction diagnostic mode in which the pressure reducing valve is controlled to operate so that whether the pressure reducing valve malfunctions is diagnosed; determination means for determining whether a condition relating to at least one from among an increase in the pressure of fuel inside the storage unit, a decrease in the pressure of fuel inside the storage unit, drive of the pressure reducing valve is fulfilled; and restriction means for restricting the control performed to drive the pressure reducing valve when the condition is determined to have been fulfilled.

[0017] With this configuration, the pressure of fuel inside the storage unit is detected to diagnose whether a malfunction is present in the pressure reducing valve, and the pressure reducing valve is driven in a malfunction diagnostic mode for diagnosing whether the pressure reducing valve malfunctions. In this case, the pressure reducing valve is controlled to close or open. As a result, the behavior of pressure when the pressure reducing valve is driven can be clarified. Therefore, the operator can diagnose whether the pressure reducing valve malfunctions or operates normally on the basis of the behavior of pressure when the pressure reducing valve is driven.

[0018] The malfunction diagnostic device according to the first and second aspect may further include diagnostic means for diagnosing whether the pressure reducing valve malfunctions on the basis of the behavior of the detected pressure of fuel inside the storage unit during the execution of the malfunction diagnostic mode.

[0019] With this configuration, in a case where the condition relating to an increase in the pressure of fuel inside the storage unit is fulfilled, the control performed to close the pressure reducing valve is restricted. As a result, the excess increase in the pressure of fuel inside the storage unit can be prevented. In a case where the condition relating to a decrease in the pressure of fuel inside the storage unit is fulfilled, the control performed to open the pressure reducing valve is restricted. As a result, the pressure reducing valve can be prevented from being erroneously diagnosed as malfunctioning when the pressure of fuel can decrease although the pressure reducing valve is not open. In a case
where the condition relating to driving the pressure reducing valve is fulfilled, the control performed to open the pressure reducing valve is restricted. As a result, the time or revolution speed at which the pressure reducing valve is controlled to open is restricted and the deterioration rate of the pressure reducing valve can be decreased. Furthermore, the control performed to open the pressure reducing valve is restricted when the pressure reducing valve is difficult to drive due to a factor other than malfunctioning, and the pressure reducing valve can be prevented from being erroneously diagnosed as malfunctioning. Therefore, it is possible to provide a malfunction diagnostic device or malfunction diagnostic method for a fuel system that can reduce the adverse effect produced by driving the pressure reducing valve in order to diagnose whether the pressure reducing valve malfunctions.

[0020] In the malfunction diagnostic device according to the first and second aspect, the condition may be a condition relating to an increase in the pressure of fuel inside the storage unit; and the restriction means may restrict the control performed to close the pressure reducing valve in a case where the condition relating to an increase in the pressure of fuel inside the storage unit is determined by the determination means to have been fulfilled.

[0021] With such a configuration, the excess increase in the pressure of fuel inside the storage unit can be prevented.

[0022] In the malfunction diagnostic device according to the first and second aspect, the condition relating to an increase in the pressure of fuel inside the storage unit is determined to have been fulfilled in at least one case from among a case in which the engine is not in an idle state, a case in which a vehicle is traveling, a case in which a pressure of fuel inside the storage unit is larger than a preset pressure, and a case in which a pressure of the fuel supplied from the fuel pump to the storage unit is higher than a preset pressure.

[0023] With such a configuration, the control performed to close the pressure reducing valve can be re-

stricted if the engine is not in an idle state. As a result, the control performed to close the pressure reducing valve can be restricted in a state in which the output shaft rotation speed of the engine can rise in a state in which the pressure of fuel supplied from the fuel pump driven by the engine to the storage unit can rise. Therefore, the excess increase in the pressure of fuel inside the storage unit can be prevented.

[0024] With such a configuration, the control performed to close the pressure reducing valve can be restricted if the vehicle travels. As a result, the control performed to close the pressure reducing valve can be restricted in a state in which the output shaft rotation speed of the engine can rise in a state in which the pressure of fuel supplied from the fuel pump driven by the engine to the storage unit can rise. Therefore, the excess increase in the pressure of fuel inside the storage unit can be prevented.

[0025] With such a configuration, the control performed to close the pressure reducing valve can be restricted if the pressure of fuel inside the storage unit is higher than a preset pressure. As a result, the control performed to close the pressure reducing valve can be restricted in a state in which the output shaft rotation speed of the engine can rise in a state in which the pressure of fuel inside the storage unit can rise. Therefore, the excess increase in the pressure of fuel inside the storage unit can be prevented.

[0026] With such a configuration, the control performed to close the pressure reducing valve can be restricted if the pressure of fuel supplied from the fuel pump to the storage unit is higher than a preset pressure. As a result, the control performed to close the pressure reducing valve can be restricted in a state in which the output shaft rotation speed of the engine can rise in a state in which the pressure of fuel inside the engine to the storage unit can rise. Therefore, the excess increase in the pressure of fuel inside the storage unit can be prevented.

[0027] In the malfunction diagnostic device according to the first and second aspect, the condition may be a condition relating to a decrease in the pressure of fuel inside the storage unit or a condition relating to a drive of the pressure reducing valve; and the restriction means may restrict the control performed to open the pressure reducing valve in a case where the condition is determined to have been fulfilled.

[0028] With such a configuration, the control performed to open the pressure reducing valve can be restricted in a case where the condition relating to a decrease in the pressure of fuel inside the storage unit is fulfilled. As a result, the pressure reducing valve can be prevented from being erroneously diagnosed as malfunctioning in a state in which the pressure of fuel can decrease although the pressure reducing valve is not opened. Furthermore, with such a configuration, the control performed to open the pressure reducing valve can be restricted in a case where the condition relating to driving the pressure reducing valve is fulfilled. As a result, the time or revolution speed at which the pressure reducing valve is controlled to open can be prevented from being too long or high. Furthermore, the control performed to open the pressure reducing valve is restricted when the pressure reducing valve is difficult to drive due to a factor other than malfunctioning, and the pressure reducing valve can be prevented from being erroneously diagnosed as malfunctioning.

[0029] In the malfunction diagnostic device according to the first and second aspect, the condition relating to a decrease in the pressure of fuel inside the storage unit may be determined to have been fulfilled in a case where the pressure of fuel inside the storage unit is lower than a preset pressure.

[0030] With such a configuration, the control performed to open the pressure reducing valve is restricted if the pressure of fuel inside the storage unit is lower than a preset pressure. As a result, the pressure reducing valve can be prevented from being erroneously diagnosed as malfunctioning in a state in which the pressure of fuel is low although the pressure reducing valve is not opened.

[0031] In the malfunction diagnostic device according to the first and second aspect, the pressure reducing valve may be driven by electric power; and the condition relating to driving the pressure reducing valve is determined to have been fulfilled in a case where a voltage of electric power supplied to the pressure reducing valve is lower than a preset voltage.

[0032] With such a configuration, the control performed to open the pressure reducing valve is restricted if the voltage supplied to the pressure reducing valve is lower than a preset voltage. As a result, the control performed to open the pressure reducing valve is restricted when the pressure reducing valve is difficult to drive even if the pressure reducing valve operates normally. Therefore, the pressure reducing valve can be prevented from being erroneously diagnosed as malfunctioning.

[0033] The malfunction diagnostic device according to the first and second aspect may further include means for determining whether the engine has been started, wherein the condition relating to driving the pressure reducing valve may be determined to have been fulfilled in a case where the determination as to whether the engine has been started is being performed.

[0034] With such a configuration, the control performed to open the pressure reducing valve is restricted if the determination as to whether the engine has been started is being performed. As a result, the control performed to open the pressure reducing valve is restricted immediately after the cranking that opens the pressure reducing valve in order to reduce the size of bubbles in the fuel or replenish the fuel supplied to the fuel injection valve. Therefore, the time or revolution speed at which the pressure reducing valve is controlled to open can be prevented from being too long or high.

[0035] In the malfunction diagnostic device according

to the first and second aspect, the condition relating to driving the pressure reducing valve may be determined to have been fulfilled in a case where the pressure reducing valve is controlled to open continuously for a period equal to or longer than a preset time.

[0036] With such a configuration, the control performed to open the pressure reducing valve is restricted if the pressure reducing valve is controlled to open continuously for a period equal to or longer than a preset time. As a result, the time in which pressure reducing valve is controlled to open can be prevented from being too long.

[0037] In the malfunction diagnostic device according to the second aspect, in the malfunction diagnostic mode, the fuel injection valve may be controlled so as to restrict the injection of fuel and the pressure reducing valve may be controlled from a closed state to an open state in a state in which the rotation speed of the fuel pump has decreased to a threshold value.

[0038] With such a configuration, in the malfunction diagnostic mode, the fuel injection valve is controlled so as to restrict the injection of fuel and the pressure reducing valve is controlled from a closed state to an open state in a state in which the rotation speed of the fuel pump has decreased to a threshold value. As a result, the pressure of fuel can be detected in a state in which the fuel injection valve and fuel pump produce little effect on the pressure of fuel. Where the pressure of fuel in this state decreases, the pressure of fuel can be said to be decreased by normal opening of the pressure reducing valve. As a result, the operator can diagnose whether the pressure reducing valve malfunctions on the basis of fuel pressure behavior affected by the operation of the pressure reducing valve. Therefore, it is possible to determine with good accuracy whether the pressure reducing valve malfunctions.

[0039] In the malfunction diagnostic device according to the first and second aspect, in the malfunction diagnostic mode, the fuel injection valve may be controlled so as to restrict the injection of fuel after the pressure reducing valve has been controlled to assume a closed state and before the pressure reducing valve is controlled to assume an open state.

[0040] With such a configuration, the fuel injection valve is controlled so as to restrict the injection of fuel after the pressure reducing valve has been controlled to assume a closed state. Where the pressure of fuel does not decrease in this state, the pressure reducing valve can be said to be normally closed and the fuel injection valve and fuel pump can be said to be in a state in which the pressure of fuel can be maintained. Therefore, it is possible to determine whether a state is assumed in which the pressure of fuel can be maintained.

[0041] In the malfunction diagnostic device according to the first and second aspect, the execution means may execute a malfunction diagnostic mode in which the fuel injection valve is controlled so as to restrict the injection of fuel and the pressure reducing valve is controlled so as to maintain a closed state in a state in which a rotation speed of the fuel pump has decreased to the threshold value.

[0042] With such a configuration, the pressure reducing valve is controlled to maintain the closed state, rather than to open. As a result, a pressure corresponding to the pressure of fuel in a case where the pressure reducing valve has not been opened due to a malfunction can be detected. Therefore, the operator can accurately diagnose whether the pressure reducing valve malfunctions on the basis of results obtained in comparing the pressure of fuel in the storage unit in a case where the pressure reducing valve has been controlled to open and the pressure of fuel in the storage unit in a case where the pressure reducing valve has been controlled to maintain the closed state.

[0043] The third aspect of the invention relates to a malfunction diagnostic method for a fuel system provided with a fuel injection valve that injects a fuel, a storage unit that stores the fuel to be supplied to the fuel injection valve, a fuel pump that supplies the fuel to the storage unit, and a pressure reducing valve that reduces a pressure of the fuel inside the storage unit in an open state. The malfunction diagnostic method includes executing a malfunction diagnostic mode in which the fuel injection valve is controlled so as to restrict the injection of fuel and the pressure reducing valve is controlled from a closed state to an open state in a state in which the rotation speed of the fuel pump has decreased to a threshold value, and detecting the pressure of fuel inside the storage unit.

[0044] With such a configuration, a fuel system is provided with a fuel injection valve that injects a fuel, a storage unit that stores the fuel to be supplied to the fuel injection valve, a fuel pump that supplies the fuel to the storage unit, and a pressure reducing valve that reduces a pressure of the fuel inside the storage unit in an open state. When it is diagnosed whether the pressure reducing valve malfunctions, a malfunction diagnostic mode is executed in which the fuel injection valve is controlled so as to restrict the injection of fuel and the pressure reducing valve is controlled from a closed state to an open state in a state in which the rotation speed of the fuel pump has decreased to a threshold value, and the pressure of fuel inside the storage unit is detected. As a result, the pressure of fuel can be detected in a state in which the fuel injection valve and fuel pump produce little effect on the pressure of fuel. Where the pressure of fuel decreases in this state, the pressure of fuel can be said to be decreased by normal opening of the pressure reducing valve. Therefore, the operator or the like can diagnose whether the pressure reducing valve malfunctions on the basis of fuel pressure behavior affected by the operation of the pressure reducing valve. As a result, a malfunction diagnostic method for a fuel system can be provided that can determine with good accuracy whether the pressure reducing valve malfunctions.

[0045] The fourth aspect of the invention relates to a

malfunction diagnostic method for a fuel system provided with a fuel injection valve that injects a fuel, a storage unit that stores the fuel that will be supplied to the fuel injection valve, a fuel pump that supplies the fuel to the storage unit, and a pressure reducing valve that reduces a pressure of the fuel inside the storage unit in an open state. The malfunction diagnostic method includes detecting a pressure of fuel inside the storage unit and executing a malfunction diagnostic mode in which the pressure reducing valve is controlled to operate so that whether the pressure reducing valve malfunctions is diagnosed.

[0046] The malfunction diagnostic method according to the third and fourth aspects may further include diagnosing whether the pressure reducing valve malfunctions on the basis of the behavior of fuel pressure inside the storage unit detected during the execution of the abnormality diagnostic mode.

[0047] The malfunction diagnostic method according to the third and fourth aspects may further include determining whether a condition relating to at least one from among an increase in the pressure of fuel inside the storage unit, a decrease in the pressure of fuel inside the storage unit, and drive of the pressure reducing valve is fulfilled, and restricting the control performed to drive the pressure reducing valve when the condition is determined to have been fulfilled.

[0048] In the malfunction diagnostic method according to the third and fourth aspect, the condition may be a condition relating to an increase in the pressure of fuel inside the storage unit, and restricting the control performed to drive the pressure reducing valve may include restricting the control performed to close the pressure reducing valve in a case where the condition relating to an increase in the pressure of fuel inside the storage unit is determined to have been fulfilled.

[0049] In the malfunction diagnostic method according to the third and fourth aspect, the condition relating to an increase in the pressure of fuel inside the storage unit may be determined to have been fulfilled in at least one case from among a case in which the engine is not in an idle state, a case in which the pressure of fuel inside the storage unit is larger than a preset pressure, and a case in which a pressure of the fuel supplied from the fuel pump to the storage unit is higher than a preset pressure.

[0050] In the malfunction diagnostic method according to the third and fourth aspect, the condition may be a condition relating to a decrease in the pressure of fuel inside the storage unit, and restricting the control performed to drive the pressure reducing valve may include restricting the control performed to open the pressure reducing valve in a case where the condition relating to a decrease in the pressure of fuel inside the storage unit is determined to have been fulfilled.

[0051] In the malfunction diagnostic method according to the third and fourth aspect, the condition relating to a decrease in the pressure of fuel inside the storage unit may be determined to have been fulfilled in a case where the pressure of fuel inside the storage unit is lower than a preset pressure.

[0052] In the malfunction diagnostic method according to the third and fourth aspect, the condition may be a condition relating to driving the pressure reducing valve, and restricting the control performed to drive the pressure reducing valve may include restricting the control performed to open the pressure reducing valve in a case where the condition relating to a driving the pressure reducing valve is determined to have been fulfilled.

[0053] In the malfunction diagnostic method according to the third and fourth aspect, the pressure reducing valve may be driven by electric power, and the condition relating to driving the pressure reducing valve may be determined to have been fulfilled in a case where a voltage of electric power supplied to the pressure reducing valve is lower than a preset voltage.

[0054] The malfunction diagnostic method according to the third and fourth aspect may further include determining whether the engine has been started, and the condition relating to driving the pressure reducing valve may be determined to have been fulfilled in a case where the determination as to whether the engine has been started is being performed.

[0055] In the malfunction diagnostic method according to the third and fourth aspect, the condition relating to driving the pressure reducing valve may be determined to have been fulfilled in a case where the pressure reducing valve is controlled to open continuously for a period equal to or longer than a preset time.

[0056] In the malfunction diagnostic method according to the third and fourth aspect, in the malfunction diagnostic mode, the fuel injection valve may be controlled so as to restrict the injection of fuel and the pressure reducing valve may be controlled from a closed state to an open state in a state in which the rotation speed of the fuel pump has decreased to a threshold value.

[0057] In the malfunction diagnostic method according to the third and fourth aspect, in the malfunction diagnostic mode, the fuel injection valve may be controlled so as to restrict the injection of fuel after the pressure reducing valve has been controlled to assume a closed state and before the pressure reducing valve is controlled to assume an open state.

[0058] With such a configuration, the fuel injection valve is controlled so as to restrict the injection of fuel after the pressure reducing valve has been controlled to assume a closed state. Where the pressure of fuel does not decrease in this state, the pressure reducing valve can be said to be normally closed and the fuel injection valve and fuel pump can be said to be in a state in which the pressure of fuel can be maintained. Therefore, it is possible to determine whether a state is assumed in which the pressure of fuel can be maintained.

[0059] In the malfunction diagnostic method according to the third and fourth aspect, in the malfunction diagnostic mode, the fuel injection valve may be controlled so as to restrict the injection of fuel and the pressure reducing

valve may be controlled so as to maintain a closed state thereof in a state in which a rotation speed of the fuel pump has decreased to the threshold value.

[0060] With such a configuration, the pressure reducing valve is controlled to maintain the closed state, rather than to be opened. As a result, a pressure corresponding to the pressure of fuel in a case where the pressure reducing valve has not been opened due to a malfunction can be detected. Therefore, the operator can accurately diagnose whether the pressure reducing valve malfunctions on the basis of results obtained in comparing the pressure of fuel in the storage unit in a case where the pressure reducing valve has been controlled to open and the pressure of fuel in the storage unit in a case where the pressure reducing valve has been controlled to maintain the closed state.

BRIEF DESCRIPTION OF THE DRAWINGS

[0061] The foregoing and further objects, features and advantages of the invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

FIG. 1 is a schematic structural diagram of the engine according to the first embodiment of the invention;
FIG. 2 is a functional block diagram of the Electronic Control Unit (ECU) according to the first embodiment of the invention;
FIG. 3 is a flowchart illustrating the control structure of program executed by the ECU according to the first embodiment of the invention;
FIG. 4 is a timing chart illustrating the transition of pressure of fuel and the like in the embodiment of the invention;
FIG. 5 is a schematic structural diagram of the engine according to the second embodiment of the invention;
FIG. 6 is a functional block diagram of the ECU according to the second embodiment of the invention; and
FIG. 7 illustrates conditions for restricting the drive of the pressure reducing valve according to the second embodiment of the invention.

DETAILED DESCRIPTION OF EMBODIMENTS

[0062] An embodiment of the invention will be described below with reference to the appended drawings. In the explanation below, like elements are denoted by like numerals. Names and functions of such elements are identical. Therefore, detailed explanation thereof is omitted.

[0063] An engine 100 of a vehicle having installed thereon a malfunction diagnostic device of the first embodiment of the invention will be described below with reference to FIG. 1. The engine 100 is a diesel engine. An internal combustion engine other than the diesel engine may be also used. The engine 100 is provided with a plurality of cylinders.

[0064] The air taken into the engine 100 is filtered with an air cleaner 102 and compressed by a compressor 104 of a turbocharger. The compressed air is cooled by heat exchange with external air in an intercooler 106 and introduced in a combustion chamber via an intake tube 108 and an intake manifold 110. The amount of new air in the air introduced in the combustion chamber is controlled by a throttle valve 112. The opening degree of the throttle valve 112 is controlled by an ECU 200. A configuration in which the throttle valve 112 is not provided may be also used.

[0065] A fuel pressurized by a supply pump 114 and stored in a common rail 116 is injected by an injector 118 into the combustion chamber. Drive power is generated by the engine 100 as a result of combustion of the air and fuel mixture in the combustion chamber.

[0066] The supply pump 114 is connected to an output shaft (crankshaft) of the engine 100 and driven by the rotation of the output shaft. The fuel is supplied from the supply pump 114 to the common rail 116. Furthermore, the flow rate of the fuel supplied from the supply pump 114 to the common rail 116 is controlled correspondingly to the opening degree of a suction control valve provided in the supply pump 114. Therefore, the supply of fuel from the supply pump 114 to the common rail 116 can be also stopped in a state in which the output shaft of the engine 100 rotates. A supply pump driven by an electric motor may be also used.

[0067] The injector 118 is provided for each cylinder. A target injection period of the fuel is determined according to a map having, for example, an accelerator depression amount, a rotation speed of the output shaft of the engine 100, and vehicle speed as parameters. A conventional typical procedure may be used as a method for setting the target injection period, and redundant explanation thereof is herein omitted.

[0068] The amount of fuel injected from the injector 118 is determined according to a map having, for example, an accelerator depression amount, a rotation speed of the output shaft of the engine 100, and vehicle speed as parameters. In an idle mode, the injected amount of fuel is set by Idle Speed Control (ISC) such that the rotation speed of the output shaft of the engine 100 becomes a predetermined target rotation speed. A conventional typical procedure may be used as a method for setting the injected amount of fuel, and redundant explanation thereof is herein omitted.

[0069] The gas mixture after combustion, that is, exhaust gas, is guided to an exhaust manifold 120, passed through a turbine 122 of the turbocharger, purified with a catalyst 124, and released to the atmosphere.

[0070] Part of the exhaust gas is recirculated via an Exhaust Gas Recirculation (EGR) pipe 126 connected to the exhaust manifold 120. The exhaust gas flowing in

the EGR pipe 126 is passed through an oxidation catalyst 128 and cooled by heat exchange with cooling water performed in an EGR cooler 130. The cooled exhaust gas is recirculated via the EGR valve 132 to the intake side downstream of the throttle valve 112.

[0071] The amount of recirculating exhaust gas (EGR amount) is regulated by the opening degree of the EGR valve 132. The EGR valve opening degree is controlled by an EGR valve linear solenoid 134. During normal operation, the EGR valve opening degree is controlled so as to close the EGR valve 132, that is, so as to decrease the EGR amount as the torque of the engine 100 rises. More specifically, the EGR valve opening degree detected using an EGR valve lift sensor 136 is inputted to the ECU 200 and the EGR valve opening degree is feedback controlled so that the intake oxygen concentration that changes due to EGR assumes a target value corresponding to the state (engine revolution speed, supercharge pressure, temperature of various parts, load, intake air amount) of the engine 100. The operation system of the EGR valve 132 may use not only the EGR valve linear solenoid 134, but also a negative pressure or a motor.

[0072] A pressure reducing valve 138 is provided in the common rail 116. Where the pressure reducing valve 138 is open, the fuel located in the common rail 116 is discharged and the pressure of fuel inside the common rail 116 decreases. The fuel discharged from the pressure reducing valve 138 is returned to the fuel tank.

[0073] Signals from an output shaft rotation speed sensor (crank position sensor) 202, an accelerator depression amount sensor 204, a vehicle speed sensor 206, and a pressure sensor 208 are inputted in the ECU 200.

[0074] The output shaft rotation speed sensor 202 detects the output shaft rotation speed of the engine 100. The accelerator depression amount sensor 204 detects the opening degree of the accelerator pedal. The vehicle speed sensor 206 detects the speed of the vehicle where the engine 100 is installed. For example, the vehicle speed is detected from the output shaft rotation speed of a transmission connected to the engine 100.

[0075] The pressure sensor 208 detects the pressure of fuel in the common rail 116. The pressure detected by the pressure sensor 208 is stored in a Random Access memory (RAM) 210 of the ECU 200.

[0076] The ECU 200 performs computations on the basis of signals sent from the sensors and also programs and maps stored in the memory. The engine 100 is thus controlled by the ECU 200.

[0077] Functions of the ECU 200 in the embodiment will be explained below with reference to FIG 2. The functions of the ECU 200 that are explained below may be realized by software or hardware.

[0078] The ECU 200 is provided with a closing control unit 300, a stop control unit 302, and an opening-closing control unit 304.

[0079] The closing control unit 300 performs control so as to close the pressure reducing valve 138 when an operator diagnoses whether the pressure reducing valve 138 operates normally or malfunctions, for example, in an automobile repair shop. The closing control valve 300 forcibly performs control to close the pressure reducing valve 138 when a command signal is received from a diagnostic device (diagnostic tool) designed to allow the operator to perform malfunction diagnostic of the pressure reducing valve 138 in a state in which the diagnostic device is connected to the ECU 200.

[0080] The stop control unit 302 controls the injector 118 so as to stop the injection of fuel after the pressure reducing valve 138 has been controlled to close and also controls the supply pump 114 so as to stop the supply of fuel from the supply pump 114 to the common rail 116.

[0081] Where the output shaft rotation speed of the engine 100 decreases to a threshold value, that is the output shaft rotation speed of the engine 100 becomes equal to or less than the threshold value after the injection of fuel has been stopped, the opening-closing control unit 304 performs forced control to open the pressure reducing valve 138. For example, a value at which the effect of the supply pump 114 on the pressure of fuel inside the common rail 116 is practically eliminated can be set as the threshold value.

[0082] Furthermore, where the output shaft rotation speed of the engine 100 decreases to the threshold value, the opening-closing control unit 304 conducts forced control to maintain the close state of the pressure reducing valve 138, instead of performing control to open the pressure reducing valve 138.

[0083] Thus in the embodiment, the ECU 200 executes a first diagnostic mode in which the pressure reducing valve 138 is opened and a second diagnostic mode in which the closed state of the pressure reducing valve 138 is maintained when diagnosing whether the pressure reducing valve 138 malfunctions or operates normally. For example, after either of the first diagnostic mode and second diagnostic mode has been executed, the other diagnostic mode is executed.

[0084] In the embodiment, in a case where the output shaft rotation speed of the engine 100 has decreased to the threshold value, it is determined that the rotation speed of the supply pump 114 has decreased to a threshold value. Thus, whether the rotation speed of the supply pump 114 has decreased to the threshold value is indirectly determined based on whether the output shaft rotation speed of the engine 100 has decreased to the threshold value. The rotation speed of the supply pump 114 may be also detected directly.

[0085] The pressure of fuel detected by the pressure sensor 208 in each diagnostic mode is inputted, for example via the ECU 200, in the diagnostic device. The operator determines whether the pressure reducing valve 138 malfunctions or operates normally based on the behavior (change) of pressure of fuel displayed, for example, on the display of the diagnostic devices. Whether the pressure reducing valve 138 malfunctions or normal may be also diagnosed by the ECU 200.

[0086] A control structure of a program executed by

the ECU 200 in the embodiment will be explained with reference to FIG. 3. The program explained hereinbelow is executed when the operator diagnoses whether the pressure reducing valve 138 malfunctions or normal. The program executed by the ECU 200 may be stored on a recording medium such as a Compact Disk (CD) or Digital Versatile Disk (DVD) and commercially circulated. The program may be stored in the diagnostic device, rather than in the ECU 200, and the diagnostic device may execute the program.

[0087] In step (step is hereinbelow abbreviated as S) 100, the ECU 200 performs the control to close the pressure reducing valve 138. In S102, the ECU 200 controls the injector 118 so as to stop the fuel injection and controls the supply pump 114 so as to stop the supply of fuel from the supply pump 114 to the common rail 116.

[0088] In S104, the ECU 200 determines whether the output shaft rotation speed of the engine 100 has decreased to the threshold value, that is, whether the revolution speed of the supply pump 114 has decreased to the threshold value. Where the output shaft rotation speed of the engine 100 has decreased to the threshold value (YES in step S104), the processing advances to S106. Otherwise (NO in S104), the processing returns to S104.

[0089] In S106, the ECU 200 determines whether to perform the control so as to open the pressure reducing valve 138, or so as to maintain the closed state of the pressure reducing valve 138. In a case where the control will be performed so as to open the pressure reducing valve 138 (OPEN in S106), the processing advances to S108. Where the control will be performed so as to maintain the closed state of the pressure reducing valve 138 (CLOSE in S106), the processing moves to S110.

[0090] In S108, the ECU 200 performs the control so as to open the pressure reducing valve 138. In S110, the ECU 200 performs the control so as to maintain the closed state of the pressure reducing valve 138.

[0091] The operation of the malfunction diagnostic device of the embodiment will be explained below based on the above-described structure and flowchart.

[0092] Where the malfunction diagnostic of the pressure reducing valve 138 is performed, the pressure reducing valve 138 is controlled to close at a time T1 shown in FIG 4 (S100). Then, at a time T2, the injector 118 is controlled so as to stop the injection of fuel, and the supply pump 114 is controlled so as to stop the supply of fuel from the supply pump 114 to the common rail 116 (S102).

[0093] In a case where the pressure of fuel drops abruptly after the pressure reducing valve 138 has been closed and the fuel injection and fuel supply have been stopped, as shown by a dot-dash line in FIG. 4, the fuel can be said to leak from at least one of the injector 118, supply pump 114, and pressure reducing valve 138.

[0094] A case where the pressure is maintained as shown by a solid line in FIG. 4, or
where the pressure decreases gradually can be said to correspond to a state in which the pressure reducing valve 138 operates normally and the injector 118 and supply pump 114 can maintain the pressure of fuel.

[0095] Where the output shaft rotation speed of the engine 100 decreases to the threshold value at a time T3 shown in FIG. 4 (YES in S104), it is determined whether to perform the control so as to open the pressure reducing valve 138 or so as to maintain the closed state of the pressure reducing valve 138 (S106). In a case where the control is performed so as to maintain the closed state of the pressure reducing valve 138 (S110, CLOSE in S106), if the pressure reducing valve 138 is normal, the pressure of fuel decreases gradually, as shown by a two-dot - dash line shown in FIG. 4.

[0096] In a case where the control is performed so as to open the pressure reducing valve 138 (S108, OPEN in S106), if the pressure of fuel decreases rapidly, as shown by a solid line in FIG. 4, the pressure of fuel can be said to be decreased by normal opening of the pressure reducing valve 138.

[0097] Where the pressure of fuel decreases gradually, as in the case of performing the control so as to maintain the closed state of the pressure reducing valve 138, the pressure reducing valve 138 can be said to remain closed. In this case, the pressure reducing valve 138 can be said to malfunction.

[0098] Therefore, where the pressure of fuel in the case of performing the control so as to open the pressure reducing valve 138 is substantially equal to the pressure of fuel in the case of performing the control so as to maintain the closed state of the pressure reducing valve 138, the pressure reducing valve 138 can be determined to malfunction.

[0099] By contrast, where the pressure of fuel in the case of performing the control so as to open the pressure reducing valve 138 decreases with respect to the pressure of fuel in the case of performing the control so as to maintain the closed state of the pressure reducing valve 138, the pressure of fuel can be said to be decreased by normal opening of the pressure reducing valve 138. Therefore, the pressure reducing valve 138 can be determined to operate normally.

[0100] As described hereinabove, with the malfunction diagnostic device of the embodiment, where the malfunction diagnostic of the pressure reducing valve is performed, the injector is controlled so as to stop fuel injection. If the output shaft rotation speed of the engine then decreases to the threshold value, the pressure reducing valve is controlled to open. As a result, the pressure of fuel in a state with a small effect of the injector and supply pump can be detected. Where the pressure of fuel decreases in this state, the pressure of fuel can be said to be decreased by normal opening of the pressure reducing valve. Therefore, the operator can diagnose whether the pressure reducing valve malfunctions on the basis of the behavior of fuel pressure affected by the operation of the pressure reducing valve. As a result, it is possible to determine with good accuracy whether the pressure reducing valve malfunctions.

[0101] An engine 100 of a vehicle carrying a malfunction diagnostic device of the second embodiment of the invention will be explained below with reference to FIG. 5. The malfunction diagnostic device of the embodiment can reduce the adverse effect produced by driving the pressure reducing valve in order to diagnose whether the pressure reducing valve malfunctions.

[0102] In the embodiment a pressure reducing valve 138 is an electromagnetic valve driven by power supplied from an auxiliary battery 140.

[0103] The pressure reducing valve 138 is controlled to opened not only in a case
where the pressure of fuel inside a common rail 116 is higher than a target pressure, but also, for example, during cranking performed to start the engine 100. The pressure reducing valve 138 is controlled to open during cranking in order to supply the fuel decompressed by the pressure reducing valve 138 into a displacement expansion chamber in an injector 118 and decrease the size of bubbles contained in the fuel, or in order to replenish the fuel supplied into the injector 118. A conventional method may be used for controlling the pressure reducing valve 138 during cranking, and the detailed explanation thereof is herein omitted.

[0104] In addition to signals from an output shaft rotation speed sensor (crank position sensor) 202, an accelerator depression amount sensor 204, a vehicle speed sensor 206, and a pressure sensor 208, a signal from a voltage sensor 212 is also inputted in an ECU 200.

[0105] The voltage sensor 212 detects a voltage of the auxiliary battery 140, and is, a voltage supplied from the auxiliary battery 140 to the pressure reducing valve 138.

[0106] The ECU 200 performs computations based on the signal sent from the aforementioned sensors and also the program and map stored in the memory. The ECU 200 thus controls the engine 100.

[0107] Functions of the ECU 200 in the embodiment will be described below with reference to FIG. 6. The below-described functions of the ECU 200 may be realized with software or hardware.

[0108] The ECU 200 is provided with a control unit 310, a determination unit 306, and a restriction unit 308. The control unit 310 includes a closing control unit 300, a stop control unit 302, and an opening-closing control unit 304 in the first embodiment and performs control so as to drive the pressure reducing valve 138, injector 118, and supply pump 114 in a preset diagnostic mode when the operator diagnoses whether the pressure reducing valve 138 malfunctions or operates normally, for example, in an automobile repair shop.

[0109] For example, where a command signal is received from a diagnostic device (diagnostic tool) in a state in which the diagnostic device designed to allow the operator to perform malfunction diagnostic of the pressure reducing valve 138 is connected to the ECU 200, the control is performed so as to drive the pressure reducing valve 138, injector 118, and supply pump 114 in a preset diagnostic mode.

[0110] In the embodiment, similarly to the first embodiment, as shown in FIG. 4, first, the pressure reducing valve 138 is forcibly controlled to close at a time T1. After the pressure reducing valve 138 has been controlled to close, the injector 118 is controlled so as to stop the injection of fuel and the supply pump 114 is controlled so as to stop the supply of fuel from the supply pump 114 to the common rail 116 at a time T2.

[0111] Where the output shaft rotation speed of the engine 100 decreases to a threshold value, that is, the output shaft rotation speed of the engine 100 becomes equal to or less than a threshold value at a time T3 after the injection of fuel has been stopped, the pressure reducing valve 138 is forcibly controlled to opened. For example, a value at which the effect of the supply pump 114 on the pressure of fuel inside the common rail 116 is practically eliminated can be set as the threshold value. The pressure reducing valve 138 is controlled to open continuously for a preset time ΔT.

[0112] In the embodiment, the rotation speed of the supply pump 114 is determined to have decreased to a threshold value in a case where the output shaft rotation speed of the engine 100 decreases to a threshold value. Thus, whether the rotation speed of the supply pump 114 has decreased to the threshold value is indirectly determined based on whether the output shaft rotation speed of the engine 100 has decreased to the threshold value. The rotation speed of the supply pump 114 may be also detected indirectly.

[0113] The operator determines whether the pressure reducing valve 138 malfunctions of operates normally based on the behavior (changes) of fuel pressure that is displayed, for example, on a display of the diagnostic device. Whether the pressure reducing valve 138 malfunctions or operates normally may be also diagnosed by the ECU 200.

[0114] For example, where the pressure is maintained after the pressure reducing valve 138 has been closed and the injection of fuel and fuel supply have been stopped, that is, within a period of T1 to T3 in FIG. 4, as shown by a solid line in FIG. 4, and the pressure decreases after the pressure reducing valve 138 has been controlled to open at the time T3, the pressure of fuel can be said to be decreased by normal opening of the pressure reducing valve 138. Therefore, the pressure reducing valve 138 can be diagnosed to operate normally.

[0115] In a case where the pressure of fuel drops abruptly, after the pressure reducing valve 138 has been closed and the injection of fuel and fuel supply have been stopped, that is, within a period to T1 to T3 in FIG. 4, as shown by a dot-dash line in FIG. 4, the fuel can be diagnosed to leak from at least one of the injector 118, supply pump 114, and pressure reducing valve 138.

[0116] Where the decrease ratio of the fuel pressure is low, regardless of the control performed to open the pressure reducing valve 138 at the time T3, as shown by a two-dot - dash line in FIG. 4, the pressure reducing valve 138 can be diagnosed to malfunction. A method

for diagnosing the pressure reducing valve 138 is not limited to the above-described methods.

[0117] The determination unit 306 determines whether the condition that is established to restrict the driving of the pressure reducing valve 138 is fulfilled. More specifically, the determination unit determines whether a condition relating to at least one from among an increase in the pressure of fuel inside the common rail 116, a decrease in the pressure of fuel inside the common rail 116, and driving the pressure reducing valve 138 is fulfilled.

[0118] The condition relating to an increase in the pressure of fuel inside the common rail 116 includes a condition that the engine 100 is not in an idle state (more specifically, a state stabilized in idle), a condition that the vehicle travels, a condition that the pressure of fuel inside the common rail 116, that is, a pressure detected by the pressure sensor 208 is higher than a preset upper limit value, and a condition that a pressure of fuel supplied from the supply pump 114 to the common rail 116 is higher than a preset pressure.

[0119] For example, in a case where the depression amount of the accelerator pedal is larger than zero, that is, where the accelerator pedal has been depressed, the engine 100 is determined not to be in an idle state. In a case, where the vehicle speed is larger than zero, it is determined that the vehicle travels. Where an opening degree of a suction control valve provided in the supply pump 114 is larger than a preset value, the pressure of fuel supplied from the supply mump 114 to the common rail 116 is determined to be higher than the preset value. A method for determining the conditions is not limited to the above-described methods.

[0120] The condition relating to a decrease in the pressure of fuel inside the common rail 116 includes a condition that the pressure of fuel inside the common rail 116 is lower than a preset pressure.

[0121] The condition relating to driving the pressure reducing valve 138 includes a condition that the voltage of the auxiliary battery 140 is lower than a preset voltage, a condition that the determination as to whether the engine 100 has been started is being performed, and a condition that the pressure reducing valve 138 has been controlled to open continuously for a time equal to or longer than a preset time ΔT.

[0122] For example, whether the engine 100 has been started is determined based on whether the output shaft rotation speed of the engine 100 increases to a preset rotation speed after the ignition switch has been turned ON. Therefore, the condition that the determination as to whether the engine has been started is being performed is fulfilled when the output shaft rotation speed of the engine 100 is less than a preset rotation speed after the ignition switch has been turned ON.

[0123] Where at least one condition from among the condition relating to an increase in the pressure of fuel inside the common rail 116, the condition relating to a decrease in the pressure of fuel inside the common rail 116, and the condition relating to driving the pressure reducing valve 138 is fulfilled, the restriction unit 308 restricts the control performed to drive the pressure reducing valve 138 according to the combinations in the table shown in FIG. 4. Thus, the control performed to open or close the pressure reducing valve 138 is prohibited or canceled.

[0124] As shown in FIG 7, where at least one condition from among the condition that the engine 100 is not in an idle state, the condition that the pressure of fuel inside the common rail 116, that is, a pressure detected by the pressure sensor 208 is higher than a preset upper limit value, and the condition that a pressure of fuel supplied from the supply pump 114 to the common rail 116 is higher than a preset pressure is fulfilled, the control performed to open or close the pressure reducing valve 138 is prohibited or canceled.

[0125] Furthermore, as shown in FIG. 7, the control performed to open or close the pressure reducing valve 138 is also prohibited or canceled in a case where the pressure sensor 208 malfunctions.

[0126] Where at least one condition from among the condition that the pressure of fuel inside the common rail 116 is lower than a preset pressure, the condition that the voltage of the auxiliary batter 140 is lower than a preset voltage, the condition that the determination as to whether the engine 100 has been started is being performed, and the condition that the pressure reducing valve 138 has been controlled to open continuously for a time equal to or longer than a preset time ΔT is fulfilled, the control performed to open the pressure reducing valve 138 is prohibited or canceled.

[0127] Therefore, where at least one condition from among the condition that the engine 100 is not in an idle state, the condition that the vehicle travels, the condition that the pressure of fuel inside the common rail 116 is higher than a preset upper limit value, the condition that a pressure of fuel supplied from the supply pump 114 to the common rail 116 is higher than a preset pressure, and the condition that the pressure sensor 208 malfunctions is fulfilled at the time T1 shown in FIG. 4, the control performed to close the pressure reducing valve 138 is prohibited.

[0128] Where the condition that the pressure of fuel inside the common rail 116 is higher than a preset upper limit value within a period of T1 to T3 shown in FIG. 4, the control performed to close the pressure reducing valve 138 is canceled.

[0129] Where at least one condition from among the condition that the engine 100 is not in an idle state, the condition that the vehicle travels, the condition that the pressure of fuel inside the common rail 116 is higher than a preset upper limit value, the condition that a pressure of fuel supplied from the supply pump 114 to the common rail 116 is higher than a preset pressure, and the condition that the pressure sensor 208 malfunctions is fulfilled at the time T3 shown in FIG. 4, the control performed to open the pressure reducing valve 138 is prohibited.

[0130] Where at least one condition from among the

condition that the pressure of fuel inside the common rail 116 is lower than a preset value, the condition that the voltage of the auxiliary battery 140 is lower than a preset voltage, and the condition that the determination as to whether the engine 100 has been started is being performed is fulfilled at the time T3 shown in FIG. 4, the control performed to open the pressure reducing valve 138 is prohibited.

[0131] Where the time in which the pressure reducing valve 138 has been controlled to open is equal to or longer than a preset time ΔT at the time T4 shown in FIG. 4, the control performed to open the pressure reducing valve 138 is canceled. Thus, the control performed to open the pressure reducing valve 138 is inhibited after the time T4.

[0132] As described hereinabove, when malfunction diagnostic of the pressure reducing valve is performed, where at least one condition from among the condition relating to an increase in the pressure of fuel in the common rail, the condition relating to a decrease in the pressure of fuel in the common rail, and the condition relating to driving the pressure reducing valve is fulfilled, the control performed to drive the pressure reducing valve is restricted. For example, in a case where the condition relating to an increase in the pressure of fuel inside the common rail is fulfilled, the control performed to close the pressure reducing valve is restricted. As a result, the excess increase in the pressure of fuel inside the common rail is prevented. In a case where the condition relating to a decrease in the pressure of fuel inside the common rail is fulfilled, the control performed to open the pressure reducing valve is restricted. As a result, the pressure reducing valve can be prevented from being erroneously diagnosed as malfunctioning when the pressure of fuel can decrease although the pressure reducing valve is not open. In a case where the condition relating to driving the pressure reducing valve is fulfilled, the control performed to open the pressure reducing valve is restricted. As a result, the time or revolution speed at which the pressure reducing valve is controlled to opened is restricted and the deterioration rate of the pressure reducing valve can be decreased. Furthermore, the control performed to open the pressure reducing valve is restricted when the pressure reducing valve is difficult to drive due to a factor other than malfunctioning, and the pressure reducing valve can be prevented from being erroneously diagnosed as malfunctioning. Therefore, the adverse effect produced by driving the pressure reducing valve in order to diagnose whether the pressure reducing valve malfunctions can be decreased.

[0133] While some embodiments of the invention have been illustrated above, it is to be understood that the invention is not limited to details of the illustrated embodiments, but may be embodied with various changes, modifications or improvements, which may occur to those skilled in the art, without departing from the scope of the invention according to the claims.

An ECU (200) executes a program including a step (S102) of controlling an injector so as to stop the injection of fuel and a step (S108) of controlling a pressure reducing valve (138) to open when an output shaft rotation speed of an engine (100) decreases to a threshold value (YES in S104). Whether the pressure reducing valve (138) malfunctions or operates normally is diagnosed based on the behavior of fuel pressure in a common rail (116).

Claims

1. A malfunction diagnostic device for a fuel system provided with a fuel injection valve (118) that injects a fuel, a storage unit (116) that stores the fuel to be supplied to the fuel injection valve, a fuel pump (114) that supplies the fuel to the storage unit, and a pressure reducing valve (138) that reduces a pressure of the fuel inside the storage unit in an open state, said device comprising:

   detection means (208) for detecting the pressure of fuel inside the storage unit;
   characterized by further comprising
   execution means (200) for executing a malfunction diagnostic mode in which the fuel injection valve is controlled so as to restrict the injection of fuel and the pressure reducing valve is controlled from a closed state to an open state in a state in which the rotation speed of the fuel pump has decreased to a threshold value.

2. The malfunction diagnostic device according to claim 1, further comprising:

   determination means (200) for determining whether a condition relating to at least one from among an increase in the pressure of fuel inside the storage unit, a decrease in the pressure of fuel to be detected inside the storage unit, and drive of the pressure reducing valve is fulfilled; and
   restriction means for restricting the control performed to drive the pressure reducing valve when the condition is determined to have been fulfilled.

3. The malfunction diagnostic device according to any one of claims 1 and 2, further comprising diagnostic means for diagnosing whether the pressure reducing valve malfunctions based on behavior of the detected pressure of fuel inside the storage unit during the execution of the malfunction diagnostic mode.

4. The malfunction diagnostic device according to claim 3, wherein
   the condition is a condition relating to an increase in the pressure of fuel inside the storage unit; and
   the restriction means restricts the control performed

to close the pressure reducing valve in a case where the condition relating to an increase in the pressure of fuel inside the storage unit is determined by the determination means to have been fulfilled.

5. The malfunction diagnostic device according to claim 4, wherein the condition relating to an increase in the pressure of fuel inside the storage unit is determined to have been fulfilled in at least one case from among a case in which the engine is not in an idle state, a case in which a vehicle is traveling, a case in which a pressure of fuel inside the storage unit is larger than a preset pressure, and a case in which a pressure of the fuel supplied from the fuel pump to the storage unit is higher than a preset pressure.

6. The malfunction diagnostic device according to claim 3, wherein
the condition is a condition relating to a decrease in the pressure of fuel inside the storage unit or a condition relating to a drive of the pressure reducing valve; and
the restriction means restricts the control performed to open the pressure reducing valve in a case where the condition is determined to have been fulfilled.

7. The malfunction diagnostic device according to claim 6, wherein the condition relating to a decrease in the pressure of fuel inside the storage unit is determined to have been fulfilled in a case where the pressure of fuel inside the storage unit is lower than a preset pressure.

8. The malfunction diagnostic device according to claim 6, wherein
the pressure reducing valve is driven by electric power; and
the condition relating to driving the pressure reducing valve is determined to have been fulfilled in a case where a voltage of electric power supplied to the pressure reducing valve is lower than a preset voltage.

9. The malfunction diagnostic device according to claim 6, further comprising means (200) for determining whether the engine has been started, wherein the condition relating to driving the pressure reducing valve is determined to have been fulfilled in a case where the determination as to whether the engine has been started is being performed.

10. The malfunction diagnostic device according to claim 6, wherein the condition relating to driving the pressure reducing valve is determined to have been fulfilled in a case where the pressure reducing valve is controlled to open continuously for a period equal to or longer than a preset time.

11. The malfunction diagnostic device according to any one of claims 1 to 10, wherein in the malfunction diagnostic mode, the fuel injection valve is controlled so as to restrict the injection of fuel after the pressure reducing valve has been controlled to assume a closed state and before the pressure reducing valve is controlled to assume an open state.

12. The malfunction diagnostic device according to any one of claims 1 to 5, wherein in the malfunction diagnostic mode, the fuel injection valve is controlled so as to restrict the injection of fuel and the pressure reducing valve is controlled so as to maintain a closed state in a state in which a rotation speed of the fuel pump has decreased to the threshold value.

13. A malfunction diagnostic method for a fuel system provided with a fuel injection valve (118) that injects a fuel, a storage unit (116) that stores the fuel to be supplied to the fuel injection valve, a fuel pump (114) that supplies the fuel to the storage unit, and a pressure reducing valve (138) that reduces a pressure of the fuel inside the storage unit in an open state, **characterized by** comprising:

executing a malfunction diagnostic mode in which the fuel injection valve is controlled so as to restrict the injection of fuel and the pressure reducing valve is controlled to be set from a closed state to an open state in a state in which a rotation speed of the fuel pump has decreased to a threshold value; and
detecting the pressure of fuel inside the storage unit.

Patentansprüche

1. Fehlfunktionsdiagnosevorrichtung für ein Kraftstoffsystem, das mit einem Kraftstoffeinspritzventil (118), das einen Kraftstoff einspritzt, einer Speichereinheit (116), die den Kraftstoff speichert, der dem Kraftstoffeinspritzventil zuzuführen ist, einer Kraftstoffpumpe (114), die den Kraftstoff der Speichereinheit zuführt, und einem Druckreduzierventil (138) versehen ist, das einen Druck des Kraftstoffs innerhalb der Speichereinheit in einem offenen Zustand reduziert, wobei die Vorrichtung umfasst:

eine Erfassungseinrichtung (208) zur Erfassung des Kraftstoffdrucks innerhalb der Speichereinheit,
ferner **gekennzeichnet durch**
eine Ausführungseinrichtung (200) zur Ausführung einer Fehlfunktionsdiagnosebetriebsart, in der das Kraftstoffeinspritzventil gesteuert wird, um die Einspritzung des Kraftstoffs zu begrenzen, und das Druckreduzierventil von einem ge-

schlossenen Zustand in einen offenen Zustand in einem Zustand gesteuert wird, bei dem die Drehzahl der Kraftstoffpumpe auf einen Schwellenwert abgenommen hat.

2. Fehlfunktionsdiagnosevorrichtung nach Anspruch 1, ferner mit:

einer Bestimmungseinrichtung (200) zur Bestimmung, ob eine Bedingung, die auf zumindest eine aus einer Vergrößerung des Kraftstoffdrucks innerhalb der Speichereinheit, einer Verkleinerung des Kraftstoffdrucks, der innerhalb der Speichereinheit zu erfassen ist, und einer Ansteuerung des Druckreduzierventils bezogen ist, erfüllt ist, und
einer Begrenzungseinrichtung zur Begrenzung der Steuerung, die zur Ansteuerung des Druckreduzierventils ausgeführt wird, wenn bestimmt wird, dass die Bedingung erfüllt worden ist.

3. Fehlfunktionsdiagnosevorrichtung nach einem der Ansprüche 1 und 2, ferner mit einer Diagnoseeinrichtung zur Ausführung einer Diagnose, ob das Druckreduzierventil eine Fehlfunktion aufweist, auf der Grundlage eines Verhaltens des erfassten Kraftstoffdrucks innerhalb der Speichereinheit während der Ausführung der Fehlfunktionsdiagnosebetriebsart.

4. Fehlfunktionsdiagnosevorrichtung nach Anspruch 3, wobei
die Bedingung eine Bedingung ist, die eine Vergrößerung des Kraftstoffdrucks innerhalb der Speichereinheit betrifft, und
die Begrenzungseinrichtung die Steuerung, die ausgeführt wird, um das Druckreduzierventil zu schließen, in einem Fall begrenzt, bei dem durch die Bestimmungseinrichtung bestimmt wird, dass die Bedingung, die eine Vergrößerung des Kraftstoffdrucks innerhalb der Speichereinheit betrifft, erfüllt worden ist.

5. Fehlfunktionsdiagnosevorrichtung nach Anspruch 4, wobei bestimmt wird, dass die Bedingung, die eine Vergrößerung des Kraftstoffdrucks innerhalb der Speichereinheit betrifft, in zumindest einem Fall aus einem Fall, bei dem die Kraftmaschine nicht in einem Leerlaufzustand ist, einem Fall, bei dem ein Fahrzeug fährt, einem Fall, bei dem ein Kraftstoffdruck innerhalb der Speichereinheit größer als ein voreingestellter Druck ist, und einem Fall, bei dem ein Druck des Kraftstoffs, der von der Kraftstoffpumpe der Speichereinheit zugeführt wird, höher als ein voreingestellter Druck ist, erfüllt worden ist.

6. Fehlfunktionsdiagnosevorrichtung nach Anspruch 3, wobei
die Bedingung eine Bedingung, die eine Verkleinerung in dem Kraftstoffdruck innerhalb der Speichereinheit betrifft, oder eine Bedingung ist, die eine Ansteuerung des Druckreduzierventils betrifft, und
die Begrenzungseinrichtung die Steuerung, die ausgeführt wird, um das Druckreduzierventil zu öffnen, in einem Fall begrenzt, bei dem bestimmt wird, dass die Bedingung erfüllt worden ist.

7. Fehlfunktionsdiagnosevorrichtung nach Anspruch 6, wobei in einem Fall, bei dem der Kraftstoffdruck innerhalb der Speichereinheit niedriger als ein voreingestellter Druck ist, bestimmt wird, dass die Bedingung, die eine Verkleinerung in dem Kraftstoffdruck innerhalb der Speichereinheit betrifft, erfüllt worden ist.

8. Fehlfunktionsdiagnosevorrichtung nach Anspruch 6, wobei
das Druckreduzierventil durch eine elektrische Leistung angesteuert wird, und
in einem Fall, bei dem eine Spannung einer elektrischen Leistung, die dem Druckreduzierventil zugeführt wird, niedriger als eine voreingestellte Spannung ist, bestimmt wird, dass die Bedingung, die eine Ansteuerung des Druckreduzierventils betrifft, erfüllt worden ist.

9. Fehlfunktionsdiagnosevorrichtung nach Anspruch 6, ferner mit einer Einrichtung (200) zur Bestimmung, ob die Kraftmaschine gestartet worden ist, wobei
in einem Fall, bei dem die Bestimmung dahingehend, ob die Kraftmaschine gestartet worden ist, ausgeführt wird, bestimmt wird, dass die Bedingung, die eine Ansteuerung des Druckreduzierventils betrifft, erfüllt worden ist.

10. Fehlfunktionsdiagnosevorrichtung nach Anspruch 6, wobei in einem Fall, bei dem das Druckreduzierventil gesteuert wird, um sich kontinuierlich für eine Zeitdauer zu öffnen, die größer oder gleich einer voreingestellten Zeit ist, bestimmt wird, dass die Bedingung, die eine Ansteuerung des Druckreduzierventils betrifft, erfüllt worden ist.

11. Fehlfunktionsdiagnosevorrichtung nach einem der Ansprüche 1 bis 10, wobei in der Fehlfunktionsdiagnosebetriebsart das Kraftstoffeinspritzventil gesteuert wird, um die Einspritzung des Kraftstoffs zu begrenzen, nachdem das Druckreduzierventil gesteuert worden ist, um einen geschlossenen Zustand anzunehmen, und bevor das Druckreduzierventil gesteuert wird, um einen offenen Zustand anzunehmen.

12. Fehlfunktionsdiagnosevorrichtung nach einem der Ansprüche 1 bis 5, wobei in der Fehlfunktionsdiagnosebetriebsart in einem Zustand, bei dem eine

Drehzahl der Kraftstoffpumpe auf den Schwellenwert abgenommen hat, das Kraftstoffeinspritzventil gesteuert wird, um die Einspritzung des Kraftstoffs zu begrenzen, und das Druckreduzierventil gesteuert wird, um einen geschlossenen Zustand aufrechtzuerhalten.

13. Fehlfunktionsdiagnoseverfahren für ein Kraftstoffsystem, das mit einem Kraftstoffeinspritzventil (118), das einen Kraftstoff einspritzt, einer Speichereinheit (116), die den Kraftstoff speichert, der dem Kraftstoffeinspritzventil zuzuführen ist, einer Kraftstoffpumpe (114), die den Kraftstoff der Speichereinheit zuführt, und einem Druckreduzierventil (138) versehen ist, das einen Druck des Kraftstoffs innerhalb der Speichereinheit in einem offenen Zustand reduziert, **gekennzeichnet durch**:

ein Ausführen einer Fehlfunktionsdiagnosebetriebsart, in der das Kraftstoffeinspritzventil gesteuert wird, um die Einspritzung des Kraftstoffs zu begrenzen, und das Druckreduzierventil gesteuert wird, um von einem geschlossenen Zustand in einen offenen Zustand in einem Zustand versetzt zu werden, bei dem eine Drehzahl der Kraftstoffpumpe auf einen Schwellenwert abgenommen hat, und
einem Erfassen des Kraftstoffdrucks innerhalb der Speichereinheit.

Revendications

1. Dispositif de diagnostic de dysfonctionnement pour un système de carburant pourvu d'une soupape (118) d'injection de carburant qui injecte du carburant, une unité de stockage (116) qui stocke le carburant à alimenter à la soupape d'injection de carburant, une pompe à carburant (114) qui alimente le carburant à l'unité de stockage, et une soupape (138) de réduction de pression qui réduit une pression du carburant à l'intérieur de l'unité de stockage dans un état ouvert, ledit dispositif comprenant :

un moyen de détection (208) pour détecter la pression de carburant à l'intérieur de l'unité de stockage ;
caractérisé par le fait de comprendre en outre un moyen d'exécution (200) pour exécuter un mode de diagnostic de dysfonctionnement dans lequel la soupape d'injection de carburant est commandée de manière à limiter l'injection de carburant et la soupape de réduction de pression est commandée d'un état fermé à un état ouvert dans un état où la vitesse de rotation de la pompe de carburant a diminué vers une valeur seuil.

2. Dispositif de diagnostic de dysfonctionnement selon la revendication 1, comprenant en outre :

un moyen de détermination (200) pour déterminer si une condition relative à au moins l'une d'une augmentation de la pression de carburant à l'intérieur de l'unité de stockage, d'une diminution de la pression de carburant à détecter à l'intérieur de l'unité de stockage, et d'une attaque de la soupape de réduction de pression, est remplie ; et
un moyen de restriction pour limiter la commande effectuée pour attaquer la soupape de réduction de pression lorsqu'il est déterminé que la condition a été remplie.

3. Dispositif de diagnostic de dysfonctionnement selon l'une quelconque des revendications 1 et 2, comprenant en outre un moyen de diagnostic pour diagnostiquer si la soupape de réduction de pression présente un dysfonctionnement sur la base du comportement de la pression détectée de carburant à l'intérieur de l'unité de stockage au cours de l'exécution du mode de diagnostic de dysfonctionnement.

4. Dispositif de diagnostic de dysfonctionnement selon la revendication 3, dans lequel
la condition est une condition relative à une augmentation de la pression de carburant à l'intérieur de l'unité de stockage ; et
le moyen de restriction limite la commande effectuée pour fermer la soupape de réduction de pression dans un cas où il est déterminé par le moyen de détermination que la condition relative à une augmentation de la pression de carburant à l'intérieur de l'unité de stockage a été remplie.

5. Dispositif de diagnostic de dysfonctionnement selon la revendication 4, dans lequel il est déterminé que la condition relative à une augmentation de la pression de carburant à l'intérieur de l'unité de stockage a été remplie dans au moins un cas parmi un cas dans lequel le moteur n'est pas dans un état de repos, un cas dans lequel un véhicule se déplace, un cas dans lequel une pression de carburant à l'intérieur de l'unité de stockage est supérieure à une pression préétablie, et un cas dans lequel une pression du carburant alimenté par la pompe à carburant à l'unité de stockage est supérieure à une pression préétablie.

6. Dispositif de diagnostic de dysfonctionnement selon la revendication 3, dans lequel
la condition est une condition relative à une diminution de la pression de carburant à l'intérieur de l'unité de stockage ou une condition relative à une attaque de la soupape de réduction de pression ; et
le moyen de limitation limite la commande effectuée

pour ouvrir la soupape de réduction de pression dans un cas où il est déterminé que la condition a été remplie.

7. Dispositif de diagnostic de dysfonctionnement selon la revendication 6, dans lequel il est déterminé que la condition relative à une diminution de la pression de carburant à l'intérieur de l'unité de stockage a été remplie dans un cas où la pression de carburant à l'intérieur de l'unité de stockage est inférieure à une pression préétablie.

8. Dispositif de diagnostic de dysfonctionnement selon la revendication 6, dans lequel
la soupape de réduction de pression est attaquée par une puissance électrique ; et
il est déterminé que la condition relative à une attaque de la soupape de réduction de pression a été remplie dans un cas où une tension de puissance électrique alimentée à la soupape de réduction de pression est inférieure à une tension préétablie.

9. Dispositif de diagnostic de dysfonctionnement selon la revendication 6, comprenant en outre un moyen (200) pour déterminer si le moteur a été démarré, dans lequel
il est déterminé que la condition relative à une attaque de la soupape de réduction de pression a été remplie dans un cas où la détermination selon que le moteur a été démarré ou non est effectuée.

10. Dispositif de diagnostic de dysfonctionnement selon la revendication 6, dans lequel il est déterminé que la condition relative à une attaque de la soupape de réduction de pression a été remplie dans un cas où la soupape de réduction de pression est commandée pour s'ouvrir de façon continue pendant une période supérieure ou égale à un temps préétabli.

11. Dispositif de diagnostic de dysfonctionnement selon l'une quelconque des revendications 1 à 10, dans lequel, dans le mode de diagnostic de dysfonctionnement, la soupape d'injection de carburant est commandée de manière à limiter l'injection de carburant après que la soupape de réduction de pression a été commandée afin d'adopter un état fermé et avant que la soupape de réduction de pression ne soit commandée afin d'adopter un état ouvert.

12. Dispositif de diagnostic de dysfonctionnement selon l'une quelconque des revendications 1 à 5, dans lequel, dans le mode de diagnostic de dysfonctionnement, la soupape d'injection de carburant est commandée de façon à limiter l'injection de carburant et la soupape de réduction de pression est commandée de façon à maintenir un état fermé dans un état où une vitesse de rotation de la pompe à carburant a diminué vers la valeur seuil.

13. Procédé de diagnostic de dysfonctionnement pour un système de carburant pourvu d'une soupape (118) d'injection de carburant qui injecte du carburant, d'une unité de stockage (116) qui stocke le carburant à alimenter à la soupape d'injection de carburant, d'une pompe à carburant (114) qui alimente le carburant à l'unité de stockage, et d'une soupape (138) de réduction de pression qui réduit une pression du carburant à l'intérieur de l'unité de stockage dans un état ouvert, **caractérisé par** le fait de comprendre
l'exécution d'un mode de diagnostic de dysfonctionnement dans lequel la soupape d'injection de carburant est commandée de façon à limiter l'injection de carburant et la soupape de réduction de pression est commandée de façon à être réglée d'un état fermé à un état ouvert dans un état où une vitesse de rotation de la pompe à carburant a diminué vers une valeur seuil ; et
la détection de la pression de carburant à l'intérieur de l'unité de stockage.

FIG. 1

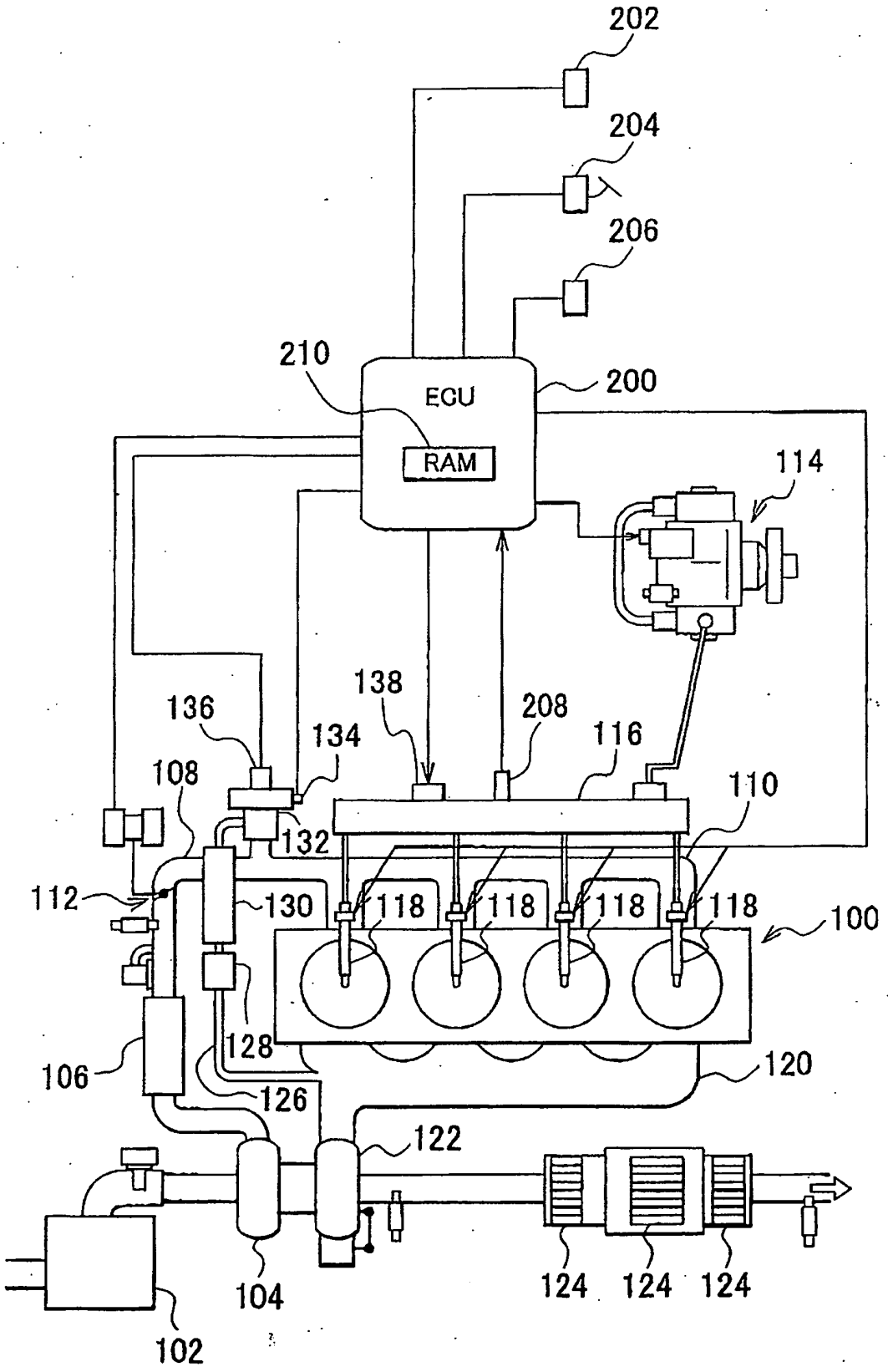
202
204
206
210
ECU
200
RAM
114
138
136
208
134
116
108
110
132
112
130
118
118
118
118
100
128
106
120
126
122
124
124
124
104
102

FIG. 2

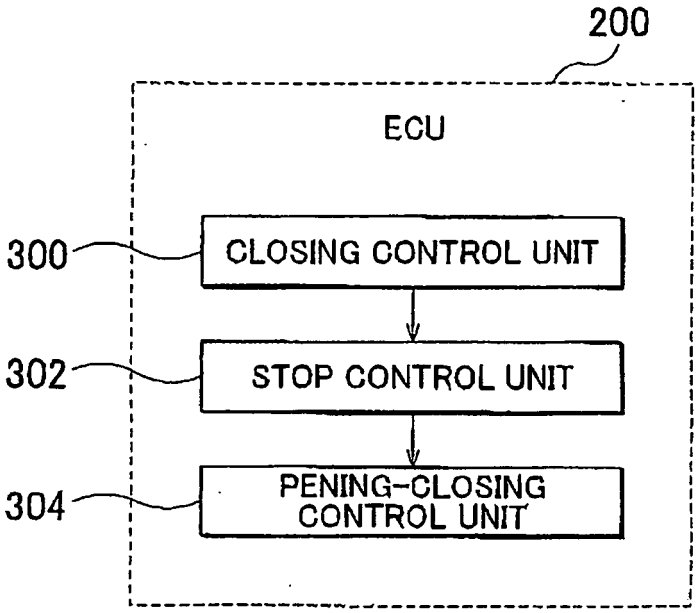
200
ECU
300
CLOSING CONTROL UNIT
302
STOP CONTROL UNIT
304
PENING-CLOSING CONTROL UNIT

FIG. 3

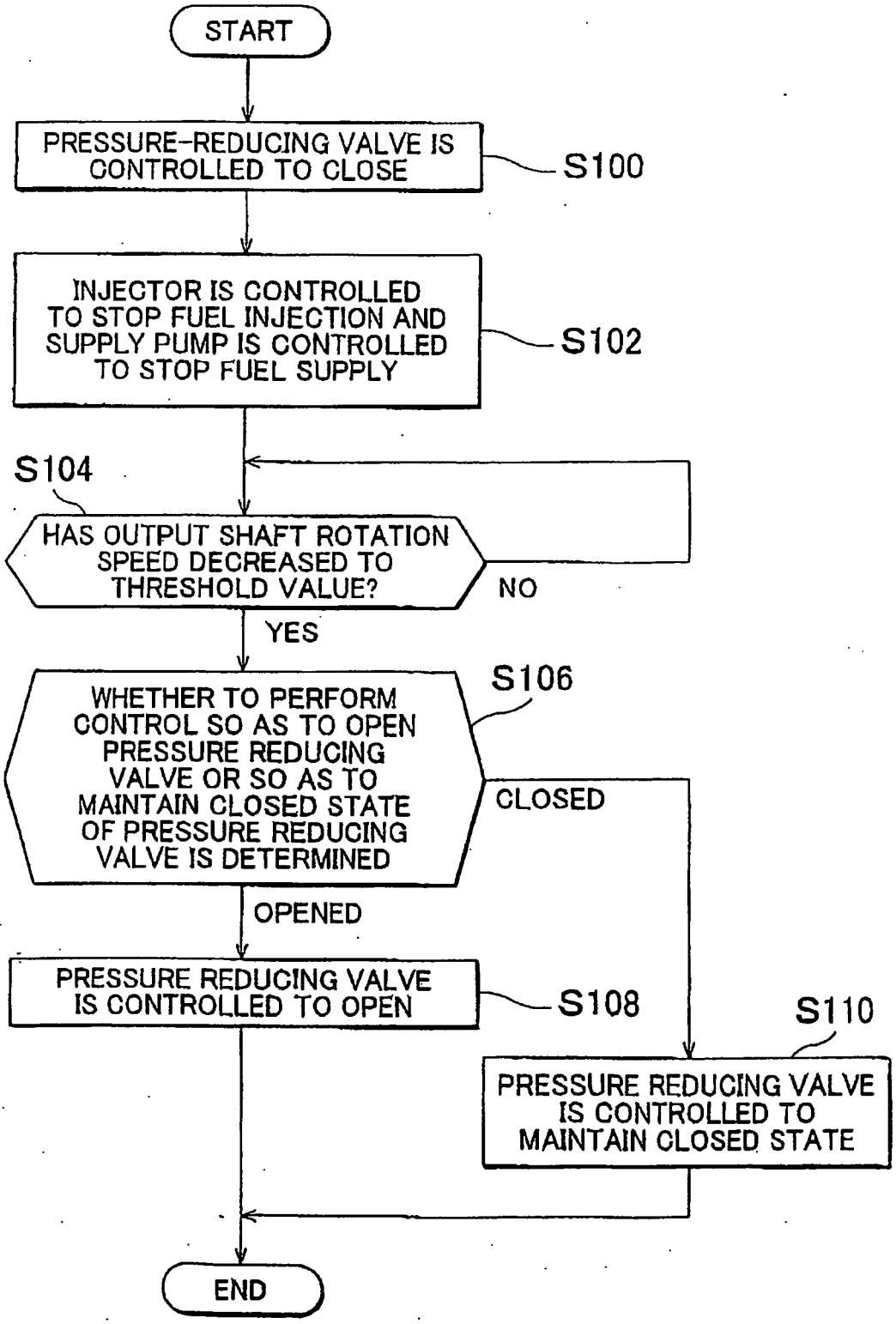
START
PRESSURE-REDUCING VALVE IS CONTROLLED TO CLOSE
S100
INJECTOR IS CONTROLLED TO STOP FUEL INJECTION AND SUPPLY PUMP IS CONTROLLED TO STOP FUEL SUPPLY
S102
S104
HAS OUTPUT SHAFT ROTATION SPEED DECREASED TO THRESHOLD VALUE?
NO
YES
S106
WHETHER TO PERFORM CONTROL SO AS TO OPEN PRESSURE REDUCING VALVE OR SO AS TO MAINTAIN CLOSED STATE OF PRESSURE REDUCING VALVE IS DETERMINED
CLOSED
OPENED
PRESSURE REDUCING VALVE IS CONTROLLED TO OPEN
S108
S110
PRESSURE REDUCING VALVE IS CONTROLLED TO MAINTAIN CLOSED STATE
END

FIG. 4

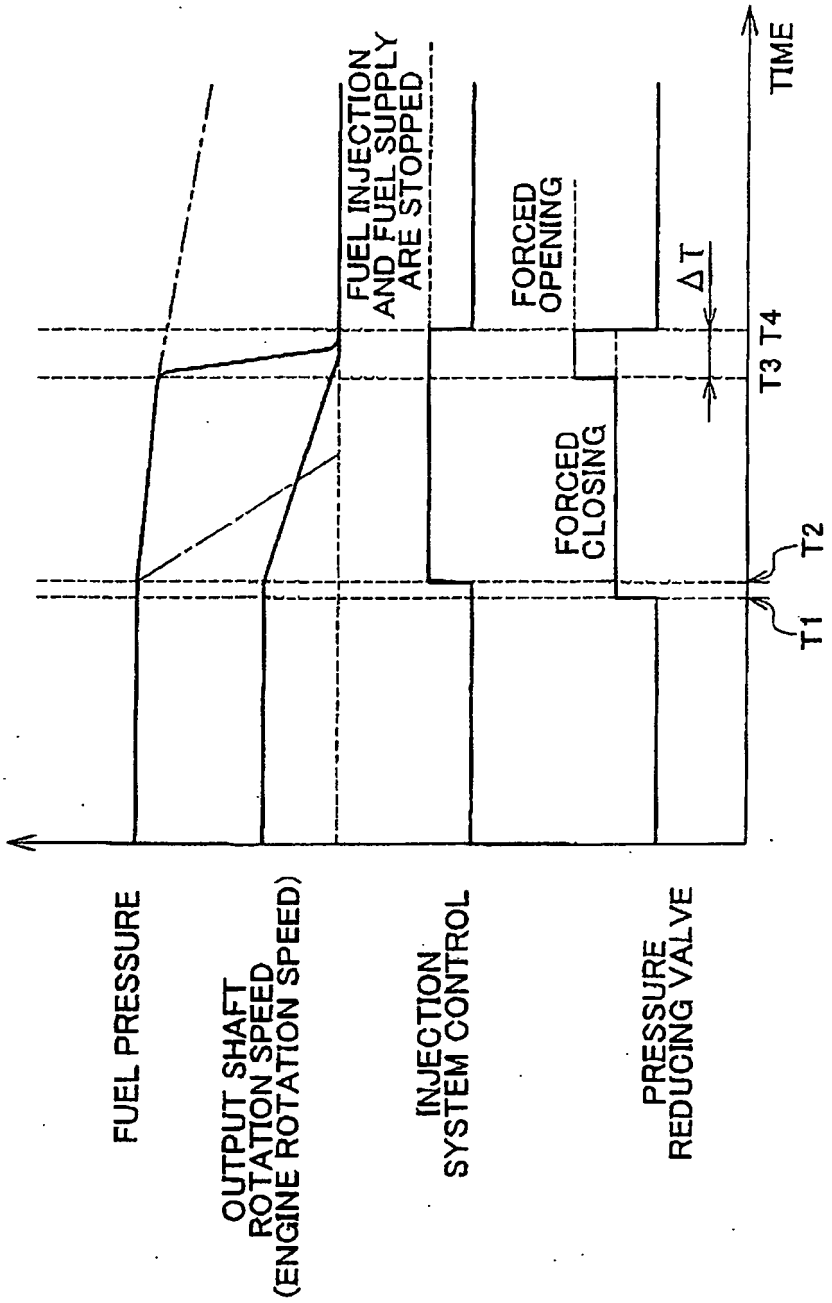
FUEL PRESSURE
OUTPUT SHAFT ROTATION SPEED (ENGINE ROTATION SPEED)
INJECTION SYSTEM CONTROL
PRESSURE REDUCING VALVE
FUEL INJECTION AND FUEL SUPPLY ARE STOPPED
FORCED OPENING
FORCED CLOSING
ΔT
T1
T2
T3 T4
TIME

FIG. 5

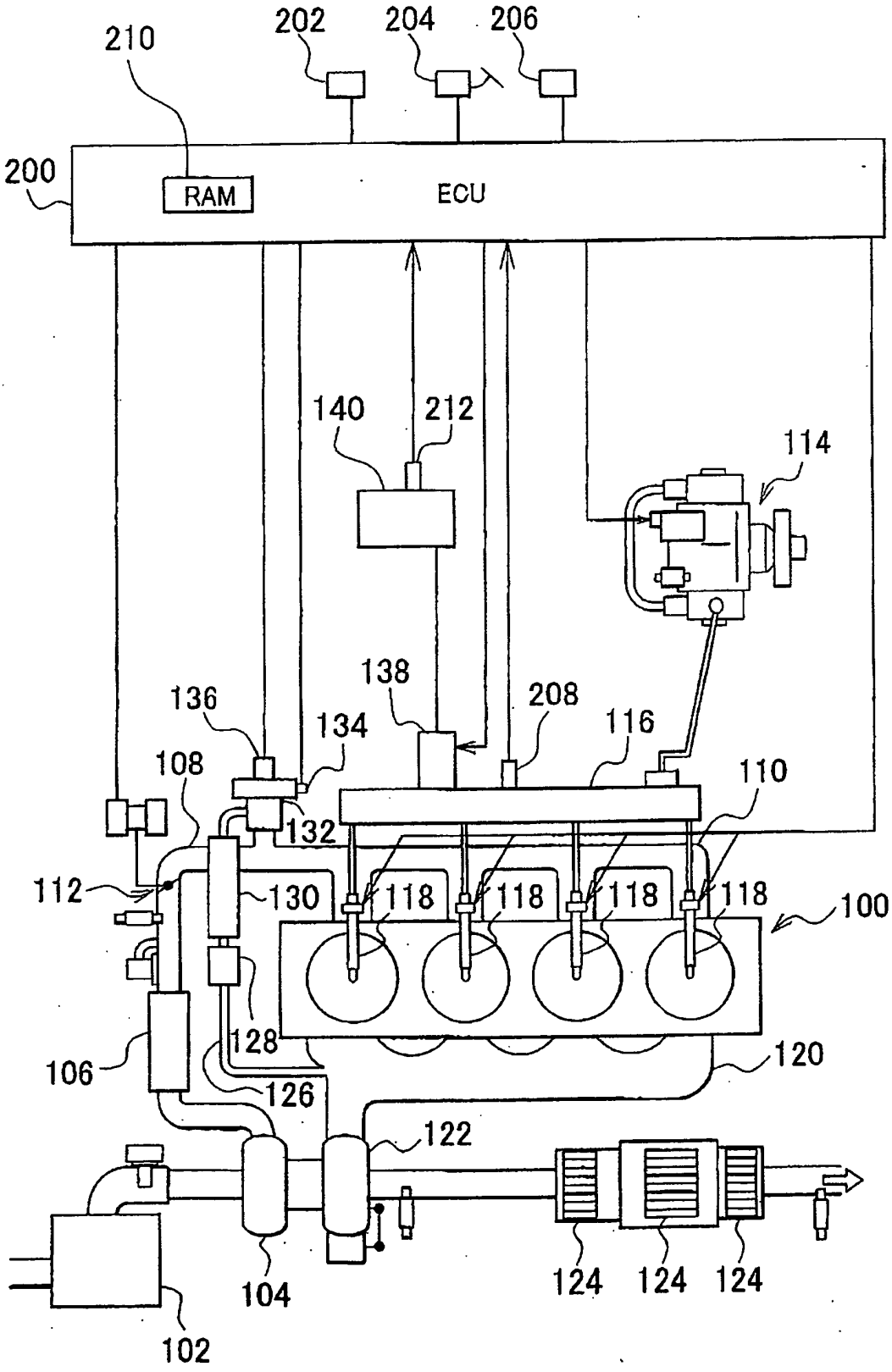
202
204
206
210
200
RAM
ECU
140
212
114
138
136
208
116
134
108
110
132
112
130
118
118
118
118
100
128
106
120
126
122
124
124
124
104
102

FIG. 6

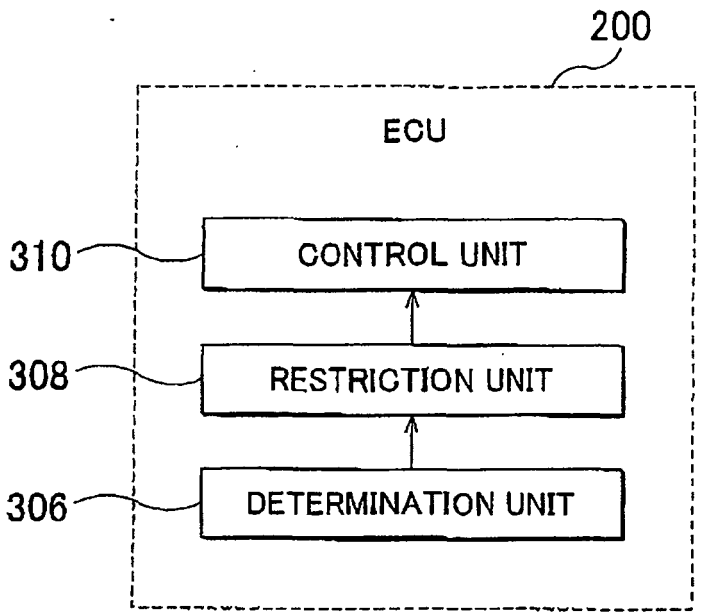
200
ECU
310
CONTROL UNIT
308
RESTRICTION UNIT
306
DETERMINATION UNIT

FIG. 7

DRIVE RESTRICTION	CONDITIONS
CONTROL PERFORMED TO CLOSE PRESSURE REDUCING VALVE IS RESTRICTED	• ENGINE IS NOT IN IDLE STATE • VEHICLE TRAVELS • PRESSURE OF FUEL IN COMMON RAIL IS HIGHER THAN PRESET UPPER LIMIT VALUE • PRESSURE OF FUEL SUPPLIED FROM SUPPLY PUMP TO COMMON RAIL IS HIGHER THAN PRESET PRESSURE • PRESSURE SENSOR MALFUNCTIONS
CONTROL PERFORMED TO OPEN PRESSURE REDUCING VALVE IS RESTRICTED	• ENGINE IS NOT IN IDLE STATE • VEHICLE TRAVELS • PRESSURE OF FUEL IN COMMON RAIL IS HIGHER THAN PRESET UPPER LIMIT VALUE • PRESSURE OF FUEL SUPPLIED FROM SUPPLY PUMP TO COMMON RAIL IS HIGHER THAN PRESET PRESSURE • PRESSURE SENSOR MALFUNCTIONS • PRESSURE OF FUEL IN COMMON RAIL IS LOWER THAN PRESET PRESSURE • PRESSURE SENSOR IS IRREGULAR • VOLTAGE OF AUXILIARY BATTERY IS LOWER THAN PRESET VOLTAGE • WHETHER ENGINE HAS BEEN STARTED IS BEING DETERMINED • PRESSURE REDUCING VALVE IS CONTROLLED TO OPEN CONTINUOUSLY FOR A PERIOD EQUAL TO OR LONGER THAT PRESET TIME ΔT

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- DE 102006000117 A1 **[0010]**