



(11) **EP 1 447 546 B1**

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention
of the grant of the patent:
13.04.2016 Bulletin 2016/15

(51) Int Cl.:
F02D 11/10 ^(2006.01) **F02D 41/30** ^(2006.01)

(21) Application number: **04003045.4**

(22) Date of filing: **11.02.2004**

(54) **Engine control unit including phase advance compensator**

Steuereinrichtung mit Phasenvorschubkompensator

Unité de commande d'un moteur avec un compensateur de l'avance de la phase

(84) Designated Contracting States:
DE FR GB

(30) Priority: **12.02.2003 JP 2003034232**

(43) Date of publication of application:
18.08.2004 Bulletin 2004/34

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Description

[0001] The present invention relates to an engine control unit for controlling engine torque or engine rotation speed in accordance with target torque of an engine. Specifically, the present invention relates to an engine control unit including a phase advance compensator for compensating a target torque response delay through phase advance compensation.

[0002] In order to stabilize engine rotation speed, a characteristic that engine torque decreases as the engine rotation speed increases is necessary. An engine operates while it is balanced at engine rotation speed at which a characteristic of demanded load torque intersects a characteristic of torque generated by the engine. An air intake quantity of an internal combustion engine (an engine) such as a diesel engine is substantially constant independently of the engine rotation speed or engine load. The engine torque is controlled by changing a fuel injection quantity injected into respective cylinders of the engine.

[0003] For instance, a diesel engine control unit disclosed in Japanese Patent Application Unexamined Publication No. H01-170741 (pp. 1-11, Figs 1 to 9) calculates a basic injection quantity Q based on the engine rotation speed and an accelerator position by using a characteristic map shown in Fig. 6 or a formula. Then, the engine control unit calculates a command injection quantity QFIN by adding an injection quantity correction value considering engine cooling water temperature, intake air temperature and the like to the basic injection quantity Q. The engine control unit controls the engine torque by changing the fuel injection quantity in accordance with the command injection quantity QFIN. The above engine control unit is configured so that the basic injection quantity Q becomes a predetermined injection quantity pattern (a governor pattern) with respect to the engine rotation speed for each accelerator position. The governor pattern is publicly known as means for expressing a static torque characteristic with respect to the engine rotation speed and the accelerator position.

[0004] However, the governor pattern of the related art represents a static balancing characteristic of the torque between the accelerator position and the engine rotation speed. Therefore, a response time required for the engine torque to reach the target torque, acceleration performance and the like with respect to the change in the accelerator position cannot be represented by linear parameters. Accordingly, it is very difficult to comprehend the transition of the engine torque quantitatively based on an elapsed time. Therefore, when drivability (acceleration feeling or deceleration feeling) with respect to the change in the accelerator position is changed in the related art, the above balancing characteristic is changed through a trial and error process, or based on experiences of a skilled adjuster. As a result, man-hours and a cost are increased.

[0005] It is therefore an object of the present invention to provide an engine control unit capable of quantitatively expressing acceleration or deceleration feeling (acceleration feeling or deceleration feeling) with respect to a change in an accelerator position with an elapsed time. Thus, a trial and error process and experiences of a skilled person are not required, and man-hours can be reduced.

[0006] According to an aspect of the present invention, an engine control unit includes phase advance compensating means for setting a response of target torque of target torque setting means during a transitional period in which an accelerator position changes. Thus, the target torque response with respect to the change in the accelerator position can be defined with an elapsed time quantitatively by using constants having physical meanings. Since acceleration or deceleration feeling (acceleration feeling or deceleration feeling) with respect to the change in the accelerator position can be quantitatively expressed with the elapsed time, adjustment of drivability can be simplified without depending on a trial and error process or experiences of a skilled person. Thus, man-hours can be reduced.

[0007] Features and advantages of embodiments will be appreciated, as well as methods of operation and the function of the related parts, from a study of the following detailed description, the appended claims, and the drawings, all of which form a part of this application. In the drawings:

Fig. 1 is a schematic diagram showing a common rail type fuel injection system according to a first embodiment of the present invention;

Fig. 2 is a flowchart showing a fuel injection quantity controlling method and a fuel discharging quantity controlling method according to the first embodiment;

Fig. 3(a) is a diagram showing control logic of an engine control unit according to the first embodiment;

Fig. 3(b) is a characteristic diagram showing a target torque response with respect to a change in an accelerator position according to the first embodiment;

Fig. 4(a) is a characteristic diagram showing a peak gain of target torque with respect to engine rotation speed according to a second embodiment of the present invention;

Fig. 4(b) is a characteristic diagram showing a time constant of phase advance compensation with respect to the engine rotation speed according to the second embodiment

Fig. 4(c) is a characteristic diagram showing a target torque response with respect to a change in an accelerator position according to the second embodiment;

Fig. 5 is a characteristic diagram showing an injection quantity pattern for calculating a basic injection quantity of a

related art; and

Fig. 6 is a characteristic diagram showing the injection quantity pattern with respect to an accelerator position and engine rotation speed of the related art.

(First Embodiment)

[0008] Referring to Fig. 1, a common rail type fuel injection system according to a first embodiment of the present invention is illustrated.

[0009] As shown in Fig. 1, the common rail type fuel injection system includes a common rail 2, a suction control type fuel supply pump 3, a suction control valve 4, multiple (four, in the present embodiment) injectors 5, actuators and an engine control unit (an ECU, hereafter) 10. The common rail 2 accumulates fuel at a high pressure corresponding to an injection pressure of the fuel injected into respective cylinders of an internal combustion engine (an engine, hereafter) 1 such as a multi-cylinder type (four-cylinder type, in the present embodiment) diesel engine mounted in a vehicle such as an automobile. The fuel supply pump 3 pressurizes drawn fuel to a high pressure. The suction control valve 4 controls a discharging quantity of the fuel discharged by the supply pump 3 in accordance with an operating state of the engine 1. The injector 5 injects the high-pressure fuel accumulated in the common rail 2 into each cylinder of the engine 1. The actuator drives a nozzle needle of the injector 5 in a valve-opening direction. The ECU 10 electronically controls the suction control valve 4 of the supply pump 3 and the actuators of the multiple injectors 5.

[0010] The common rail 2 is required to continuously accumulate the fuel at the high pressure corresponding to the fuel injection pressure. Therefore, the supply pump 3 supplies the high-pressure fuel into the common rail 2 through a fuel pipe (a high-pressure passage) 11. A pressure limiter 7 is disposed in a return pipe (a fuel return passage) 12 leading from the common rail 2 to a fuel tank 6. The pressure limiter 7 is a pressure safety valve, which opens when the fuel pressure in the common rail 2 exceeds a limit set pressure for limiting the fuel pressure in the common rail 2 to the limit set pressure or under.

[0011] The supply pump 3 has a publicly known feed pump (a low-pressure feed pump), a cam, a plunger, a pressurizing chamber (a plunger chamber) and a discharge valve. The feed pump draws the fuel from the fuel tank 6 when a pump drive shaft 9 rotates in accordance with rotation of a crankshaft 8 of the engine 1. The cam is driven to rotate by the pump drive shaft 9. The plunger is driven by the cam to reciprocate between a top dead center and a bottom dead center. The pressurizing chamber pressurizes the fuel drawn through the suction control valve 4 to a high pressure with the use of the reciprocating movement of the plunger in a cylinder. The discharge valve opens if the fuel pressure in the pressurizing chamber exceeds a predetermined value. A leak port is disposed in the supply pump 3 for preventing an increase in the fuel temperature inside the supply pump 3 to high temperature. Leak fuel from the supply pump 3 is returned to the fuel tank 6 through leak pipes (fuel leak passages) 14, 16.

[0012] The suction control valve (the SCV, hereafter) 4 is disposed in a fuel supply passage leading from the feed pump to the pressurizing chamber inside the supply pump 3. The SCV 4 regulates an opening area (an opening degree, a lifting degree of a valve member, or an opening area of a valve hole) of the fuel supply passage in order to change the fuel discharging quantity (a pump discharging quantity, a pump pressure-feeding quantity) of the fuel discharged from the supply pump 3. Thus, the SCV 4 controls the fuel pressure in the common rail 2 (the common rail pressure), or the injection pressure of the fuel injected into the respective cylinders of the engine 1 through the injectors 5.

[0013] The SCV 4 has a valve (a valve member) for regulating the opening degree of the fuel supply passage for sending the fuel from the feed pump to the pressurizing chamber, a solenoid coil (an electromagnetic coil) for driving the valve in a valve-closing direction and valve biasing means (a spring) for biasing the valve in a valve-opening direction. The SCV 4 is a pump flow rate control valve for regulating the drawing quantity of the fuel drawn into the pressurizing chamber of the supply pump 3 in proportion to SCV driving current applied to the solenoid coil through a pump driving circuit. The SCV 4 of the present embodiment is a normally open type electromagnetic valve, which fully opens when energization to the solenoid coil is stopped.

[0014] The multiple injectors 5 are mounted in accordance with the respective cylinders of the engine 1. The injectors 5 are respectively connected to downstream ends of multiple branching pipes branching from the common rail 2. The injector 5 is an electromagnetic fuel injection valve having multiple injection holes for injecting the fuel into each cylinder of the engine 1, a nozzle formed with a fuel sump upstream of the injection holes, an electromagnetic actuator for driving a nozzle needle accommodated in the nozzle in a valve-opening direction, needle biasing means (a spring) for biasing the nozzle needle in a valve-closing direction, and the like.

[0015] The fuel injection from the injector 5 of each cylinder of the engine 1 into the cylinder is controlled by turning on and off energization to an electromagnetic valve, which functions as the electromagnetic actuator for changing the fuel pressure in a back pressure control chamber of a command piston connected to the nozzle needle. More specifically, while the electromagnetic valve mounted in each injector 5 is open, the high-pressure fuel supplied from the common rail 2 into the back pressure control chamber is overflowed into a lower pressure side (the fuel tank 6) of a fuel system. Thus, the nozzle needle and the command piston are lifted against the biasing force of the needle biasing means so as

to open the multiple injection holes formed in the tip end of the nozzle. Thus, the high-pressure fuel accumulated in the common rail 2 is injected into the combustion chamber of each cylinder of the engine 1. Thus, the engine 1 is operated. Leak fuel from the injector 5 is returned to the fuel tank 6 through leak pipes (fuel return passages) 15, 16.

[0016] The ECU 10 has a microcomputer of known structure having functions of a CPU for performing control processing and calculation processing, a memory device (a memory such as ROM or RAM) for storing various programs and data, an input circuit, an output circuit, a power source circuit, an injector driving circuit (EDU), the pump driving circuit and the like. If an ignition switch is turned on (IG · ON), the ECU 10 receives ECU power supply and electronically controls the SCV 4 of the supply pump 3, the electromagnetic valves of the injectors 5 and the like based on control programs stored in the memory. If the ignition switch is turned off (IG · OFF) and the supply of the ECU power is stopped, the above control based on the control programs stored in the memory is ended compulsorily.

[0017] The voltage signal from a fuel pressure sensor 25 or sensor signals from the other various sensors are converted from analog signals into digital signals by an A/D converter and are inputted to the microcomputer incorporated in the ECU 10. The microcomputer is connected with operating state detecting means for detecting the operating state of the engine 1, such as a crank angle sensor 21 for sensing a rotation angle of the crankshaft 8 of the engine 1, an accelerator position sensor 22 for sensing an accelerator position ACCP, a cooling water temperature sensor 23 for sensing engine cooling water temperature THW, a fuel temperature sensor 24 for sensing fuel temperature THF on a pump suction side, or the temperature THF of the fuel drawn into the supply pump 3, and the like.

[0018] The crank angle sensor 21 is disposed so that the crank angle sensor 21 faces an outer periphery of an NE timing rotor attached to the crankshaft 8 of the engine 1 or the pump drive shaft 9 of the supply pump 3. Multiple convex teeth are disposed on an outer peripheral surface of the NE timing rotor at a predetermined angle interval. The crank angle sensor 21 is formed of an electromagnetic pickup coil. The crank angle sensor 21 generates pulse-shaped rotational position signals (NE signal pulses) through electromagnetic induction in accordance with approach and separation between the crank angle sensor 21 and each convex tooth. The NE signal pulses are synchronized with the rotation speed of the engine 1 or the rotation speed of the supply pump 3. The ECU 10 functions as rotation speed sensing means for sensing the engine rotation speed NE by measuring time intervals among the NE signal pulses outputted from the crank angle sensor 21.

[0019] The accelerator position sensor 22 is attached to an accelerator pedal and outputs an electric signal corresponding to engine load such as an accelerator operation degree (a depressed degree of the accelerator pedal) by an operator (a driver). The ECU 10 functions as accelerator position sensing means for calculating the accelerator position ACCP based on the electric signal inputted from the accelerator position sensor 22. The fuel pressure sensor 25 is disposed at a right end of the common rail 2 in Fig. 1 and outputs an electric signal corresponding to the fuel pressure in the common rail 2. The ECU 10 functions as injection pressure sensing means or fuel pressure sensing means for sensing the injection pressure of the fuel injected from the injectors 5 of the respective cylinders of the engine 1 into the cylinders, or the fuel pressure in the common rail 2 (the actual common rail pressure) NPC, based on the electric signal inputted from the fuel pressure sensor 25.

[0020] The ECU 10 includes fuel pressure controlling means for calculating the optimum fuel injection pressure in accordance with the operating state of the engine 1 and for controlling the common rail pressure by driving the solenoid coil of the SCV 4 through the pump driving circuit and by changing the discharging quantity of the fuel discharged from the supply pump 3. The SCV driving current applied to the solenoid coil of the SCV 4 of the supply pump 3 is feedback-controlled so that the actual common rail pressure NPC sensed by the fuel pressure sensor 25 substantially coincides with a target common rail pressure PFIN determined in accordance with the engine rotation speed NE and a command injection quantity QFIN.

[0021] The driving current applied to the SCV 4 should preferably be controlled through duty cycle control. For instance, highly precise digital control can be achieved by employing the duty cycle control in which the opening degree of the valve of the SCV 4 is changed by regulating an on/off ratio of the pump driving signal per unit time (an energization period ratio, a duty ratio) in accordance with a pressure deviation ΔP between the actual common rail pressure NPC and the target common rail pressure PFIN.

[0022] The ECU 10 includes target torque setting means, basic injection quantity setting means, command injection quantity setting means, injection timing setting means and injection period setting means. The target torque setting means calculates the target torque of the engine 1 based on the accelerator position ACCP. The basic injection quantity setting means calculates the basic injection quantity Q in accordance with the target torque of the engine 1. The command injection quantity setting means calculates the command injection quantity QFIN by adding an injection quantity correction value considering the engine cooling water temperature THW, the pump suction side fuel temperature THF and the like to the basic injection quantity Q. The injection timing setting means calculates command injection timing TFIN in accordance with the engine rotation speed NE and the command injection quantity QFIN. The injection period setting means calculates an energization period (injection pulse length, injection pulse width, an injection pulse period, a command injection period) TQ of the electromagnetic valve of the injector 5 in accordance with the actual common rail pressure NPC and the command injection quantity QFIN.

[0023] The ECU 10 includes injection ratio controlling means for performing a multi-step injection for injecting the fuel in multiple times in one cycle of the engine 1, or while the crankshaft 8 of the engine 1 rotates twice (720 °CA), with the injector 5 of a specific cylinder of the engine 1. The one cycle of the engine 1 includes an air intake stroke, a compression stroke, an expansion stroke (an explosion stroke), and an exhaust stroke in that order. In particular, the injection ratio controlling means performs the multi-step injection in one combustion stroke of a specific cylinder of the engine 1 with the injector 5 of the cylinder. For instance, by driving the electromagnetic valve of the injector 5 multiple times during the compression stroke and the expansion stroke of the engine 1, a multi-injection for performing multiple pilot injections or pre-injections before a main injection, a multi-injection for performing multiple after injections after the main injection, or a multi-injection for performing one or more pilot injections before the main injection and one or more after injections or post-injections after the main injection can be performed.

[0024] Next, a fuel injection quantity controlling method and a fuel discharging quantity controlling method of the present embodiment will be explained based on Figs. 2 and 3. The flowchart shown in Fig. 2 is repeated at a predetermined time interval after the ignition switch is turned on.

[0025] If the flowchart shown in Fig. 2 is started, engine parameters (engine operation information) such as the engine rotation speed NE, the accelerator position ACCP, the engine cooling water temperature THW, the pump suction side fuel temperature THF and the like are inputted in Step S1. Then, as shown in control logic of the ECU 10 in Fig. 3(a), the target torque setting means included in the ECU 10 calculates the target torque TE of the engine 1 from the accelerator position ACCP through a phase advance compensator 26 in Step S2.

[0026] Then, the basic injection quantity setting means included in the ECU 10 calculates the basic injection quantity Q from the target torque TE, based on a characteristic map or a formula made in advance by measurement through experimentation and the like in Step S3. Then, the command injection quantity setting means included in the ECU 10 calculates the command injection quantity QFIN by adding an injection quantity correction value ΔQ considering the engine cooling water temperature THM, the pump suction side fuel temperature THF and the like to the basic injection quantity Q in Step S4.

[0027] Then, the injection pressure controlling means included in the ECU 10 calculates the target common rail pressure PFIN from the engine rotation speed NE and the command injection quantity QFIN, based on a characteristic map or a formula made in advance by measurement through experimentation and the like in Step S5. Then, the injection timing setting means included in the ECU 10 calculates the command injection timing (injection start timing) TFIN from the engine rotation speed NE and the command injection quantity QFIN, based on a characteristic map or a formula made in advance by measurement through experimentation and the like in Step S6.

[0028] Then, the actual common rail pressure NPC is inputted in Step S7. Then, injector control variables (INJ control variables) are converted into the injection pulse width. More specifically, the injection period setting means included in the ECU 10 calculates the command injection period (the injection pulse width) TQ as the energization period of the electromagnetic valve of the injector 5 from the actual common rail pressure NPC and the command injection quantity QFIN, based on a characteristic map or a formula made in advance by measurement through experimentation and the like in Step S8.

[0029] Then, a pump control variable (an SCV control variable) is calculated in Step S9. More specifically, an SCV correction value Di is calculated in accordance with a pressure deviation between the actual common rail pressure NPC and the target common rail pressure PFIN. Subsequently, the present pump control variable (the SCV control variable) Dscv is calculated by adding the SCV correction value di to the previous SCV control variable Dscvi in Step S9. Then, the command injection timing TFIN and the command injection period TQ as the INJ control variables (the injector control variables) are set in an output stage of the ECU 10 in Step S10. Meanwhile, the pump control variable Dscv is set in the output stage of the ECU 10. Then, the processing returns to Step S1, and the above control is repeated.

[0030] If pulse-shaped injector driving current (INJ driving current, an injector injection pulse) is applied to the electromagnetic valve of the injector 5 of each cylinder through the injector driving circuit (the EDU), the fuel supplied into the back pressure control chamber of the command piston overflows into the lower pressure side of the fuel system and the fuel pressure in the back pressure control chamber decreases. Thus, the fuel pressure in the fuel sump acting on the nozzle needle in a direction for lifting the nozzle needle overcomes the biasing force of the needle biasing means. Accordingly, the nozzle needle is lifted and the multiple injection holes are connected with the fuel sump. More specifically, during the command injection period TQ after the command injection timing TFIN, the high-pressure fuel accumulated in the common rail 2 is injected into the combustion chambers of the respective cylinders of the engine 1. Thus, a predetermined quantity of the fuel corresponding to the command injection quantity QFIN is injected into the combustion chambers of the respective cylinders of the engine 1. Thus, the rotation speed of the engine 1 is controlled so that the engine torque substantially coincides with the target torque.

[0031] The basic injection quantity Q is calculated from the engine rotation speed NE and the accelerator position ACCP based on an injection quantity pattern shown in Fig. 5. A governor pattern of the related art shown in Fig. 6 shows a target torque response in the case where the accelerator position ACCP is increased from 40% to 70% stepwise (in an acceleration period). This governor pattern in Fig. 6 shows a static balancing characteristic between the accelerator

position ACCP and the engine rotation speed NE. A solid line "C" in Fig. 6 represents balancing points under an unloaded condition. The target torque TE increases as the accelerator position ACCP increases as shown by an arrow mark "ACCP" in Fig. 6.

[0032] For instance, in publicly known injector injection quantity control (fuel injection quantity control) of the related art, if the accelerator position is transitionally changed from 40% to 70% by further depressing the accelerator pedal from a state in which the accelerator pedal is depressed and held at the accelerator position ACCP of 40% while a select lever is set at an N (neutral) range, first, the target torque TE increases from approximately 50 Nm to approximately 150 Nm in accordance with the increase in the accelerator position ACCP as shown by an arrow mark "A" in Fig. 6.

[0033] At that time, the fuel injection quantity corresponding to the basic injection quantity Q, which is determined in accordance with the accelerator position ACCP after the change and the engine rotation speed NE before the change, is injected into the combustion chambers of the respective cylinders of the engine 1 from the injectors 5. Then, the engine rotation speed NE increases in accordance with the increase in the actual torque (the engine torque) of the engine 1.

[0034] The target torque TE tends to decrease as the engine rotation speed NE increases as shown in Fig. 6. Therefore, the target torque TE and the fuel injection quantity gradually decrease as the engine rotation speed NE increases as shown by an arrow mark "B" in Fig. 6. Eventually, the engine is balanced at the engine rotation speed NE (for instance, 3600 rpm) where the demanded target torque characteristic and the actual torque characteristic of the engine 1 intersect with each other as shown in Fig. 6. In the above injection quantity control of the related art, the target torque response in the case where the accelerator position ACCP is increased from 40% to 70% stepwise (in the acceleration period) is determined based on the downward inclination of the governor pattern shown in Fig. 6. Therefore, it is difficult to define the target torque response based on the elapsed time quantitatively.

[0035] A target torque response in the case where the accelerator position ACCP is changed from 40% to 70% stepwise in the common rail type fuel injection system of the present embodiment is shown in Fig. 3(b). In the common rail type fuel injection system of the present embodiment, the target torque response with respect to the change in the accelerator position ACCP is quantitatively defined based on the elapsed time by using constants such as a control gain and a time constant, which have physical meanings. As shown in Fig. 3(a), in the common rail type fuel injection system of the present embodiment, the target torque response is calculated in accordance with the inputted accelerator position ACCP through the phase advance compensator 26, instead of the governor pattern shown in Fig. 6. Thus, the target torque response is defined quantitatively based on the elapsed time. More specifically, a peak gain of the target torque corresponding to the change in the accelerator position ACCP from 40% to 70% is expressed by a constant K. Likewise, the time constant of the phase advance compensation corresponding to the change ΔTE in the target torque TE from the peak value to 63.2% of the peak value in the case where the accelerator position ACCP is changed from 40% to 70% is directly expressed by a constant ω as an elapsed time.

[0036] A transfer function of the phase advance compensation is expressed by a following expression (1). In the expression (1), "s" represents a Laplace operator.

$$TE = \{(Ks + \omega)/(s + \omega)\} \cdot ACCP, (1)$$

[0037] Thus, the peak gain of the target torque and the time constant of the phase advance compensation are defined with the constants K, ω respectively. The target torque TE with respect to the accelerator position ACCP is increased or decreased by increasing or decreasing the peak gain K. Thus, the acceleration feeling can be changed. The peak gain K is a factor that mainly affects the acceleration or deceleration feeling at the instant when the accelerator position ACCP is changed. A convergence time to the target torque TE after the acceleration can be increased or decreased by increasing or decreasing the time constant ω . Thus, the acceleration feeling can be changed. The time constant ω is a factor that mainly affects extensibility of the torque after the acceleration or the deceleration.

[0038] Thus, the fuel injection quantity (the basic injection quantity) Q in the case where the accelerator position ACCP is increased transitionally (in the acceleration period) is changed in accordance with the above target torque response. Therefore, desired acceleration feeling with respect to the accelerator operation degree (the depressed degree of the accelerator pedal) by the operator can be achieved. In the case where the accelerator position ACCP is decreased transitionally (in the deceleration period), like the acceleration period, the desired deceleration feeling with respect to the change in the accelerator operation degree (the depressed degree of the accelerator pedal) by the operator can be achieved, since the target torque response is defined quantitatively based on the elapsed time by using the constants such as the control gain (the peak gain) and the time constant, which have the physical meanings.

[0039] As explained above, in the common rail type fuel injection system of the present embodiment, the target torque response with respect to the change in the accelerator position ACCP is defined quantitatively based on the elapsed time by using the constants such as the control gain and the time constant, which have physical meanings. Thus, the acceleration or deceleration feeling (the acceleration feeling or the deceleration feeling) with respect to the change in

the accelerator position can be expressed quantitatively with the elapsed time. Therefore, the drivability, or the acceleration or deceleration feeling (the acceleration feeling or the deceleration feeling) with respect to the change in the accelerator position corresponding to the transitional change in the depressed degree of the accelerator pedal by the operator, can be adjusted quite easily without depending on the trial and error process or the experiences of the skilled person. As a result, the man-hours for the adjustment can be reduced, so the cost can be reduced.

(Second Embodiment)

[0040] Next, a setting method of the target torque response according to the second embodiment will be explained based on Fig. 4.

[0041] In the present embodiment, as shown in Fig. 4(a), the peak gain K is decreased continuously or stepwise as the engine rotation speed NE increases, so the acceleration feeling with respect to the same change in the accelerator position $ACCP$ is reduced as the engine rotation speed NE increases. More specifically, the peak gain K of the target torque TE with respect to the change in the accelerator position $ACCP$ is changed continuously or stepwise in order to change the peak value of the target torque response with respect to the change in the accelerator position $AC-CP$. Thus, the acceleration feeling or the deceleration feeling with respect to the change in the accelerator position $ACCP$ can be changed flexibly. This scheme mainly affects the acceleration feeling or the deceleration feeling at the instant when the accelerator position $ACCP$ is changed.

[0042] As shown in Fig. 4(b), the time constant ω of the phase advance compensation is increased continuously or stepwise as the engine rotation speed NE increases, so the extensibility of the engine torque or the engine rotation speed NE after the acceleration increases as the engine rotation speed NE increases. More specifically, the time constant ω of the phase advance compensation is changed continuously or stepwise in accordance with the engine rotation speed NE to change the convergence time to the target torque after the acceleration or the deceleration. Thus, the acceleration feeling or the deceleration feeling with respect to the change in the accelerator position $ACCP$ can be changed flexibly. This scheme mainly affects the extensibility of the engine torque or the engine rotation speed after the acceleration or the deceleration. For instance, if the time constant ω is increased, the extensibility of the engine torque after the acceleration is increased as shown in Fig. 4(c).

(Modifications)

[0043] In the above embodiments, the present invention is applied to the common rail type fuel injection system (the pressure accumulation type fuel injection system) as an example of the fuel injection system of the internal combustion engine such as the diesel engine. Alternatively, the present invention may be applied to a fuel injection system of an internal combustion engine of a type that has no accumulation vessel or accumulation pipe such as a common rail and supplies the high-pressure fuel from the fuel supply pump directly into the fuel injection valves or the fuel injection nozzles through high-pressure pipes.

[0044] In the above embodiments, the command injection quantity $QFIN$, the command injection timing $TFIN$ and the target common rail pressure $PFIN$ are calculated by using the crank angle sensor 21 and the accelerator position sensor 22 as the operating condition detecting means for detecting the operating conditions of the engine 1. The command injection quantity $QFIN$, the command injection timing $TFIN$ and the target common rail pressure $PFIN$ may be corrected with the detection signals (the engine operation information) outputted from the operating condition detecting means, such as the cooling water temperature sensor 23, the fuel temperature sensor 24 and the other sensors (for instance, an intake temperature sensor, an intake pressure sensor, a cylinder determination sensor, an injection timing sensor and the like).

[0045] A peak gain of target torque with respect to a change in an accelerator position from 40% to 70% is expressed by a constant K . A time constant of phase advance compensation corresponding to a period for the target torque to change from a peak value to 63.2% of the peak value in the case where the accelerator position is changed from 40% to 70% is expressed by a constant ω . A target torque response with respect to the change in the accelerator position is calculated through a phase advance compensator (26) by using the peak gain K and the time constant ω , which have physical meanings. Thus, the target torque response with respect to the change in the accelerator position can be defined quantitatively, directly based on an elapsed time.

Claims

1. An engine control unit (10), including accelerator position sensing means (22) for sensing an accelerator position corresponding to an operation degree of an accelerator by an operator, a target torque setting means (S2) for calculating a target torque of an engine (1) based on the accelerator position, and an injection quantity setting means

(S3, S4) for calculating a fuel injection quantity (QFIN) of fuel injected into a cylinder of the engine (1) in accordance with the target torque,
wherein the engine control unit (10) controls the engine torque or engine rotation speed by changing the fuel injection quantity (QFIN), and

wherein the target torque setting means (S2) includes a phase advance compensating means (26) for setting a response of the calculated target torque in a transitional period, in which the accelerator portion changes,

characterized in that

the phase advance compensating means (26) calculates a transfer function, which satisfies the following equation:

$$TE = \{ (Ks + \omega) / (s + \omega) \} \cdot ACCP,$$

where ACCP represents the accelerator position, TE is the target torque, K is a peak gain of the target torque with respect to the change in the accelerator position, ω is a time constant of the phase advance compensation and s is a Laplace operator,

wherein by setting the time constant (ω) a convergence time is set for the target torque (TE) to change from a peak value corresponding to the peak gain (K) to a target torque point, which is statically balanced with the engine rotation speed (NE) after the change in the accelerator position (ACCP).

2. The engine control unit (10) as claimed in claim 1, wherein
the phase advance compensating means (26) calculates a transfer function, which satisfies a following equation:

$$TE = \{ (Ks + \omega) / (s + \omega) \} \cdot ACCP,$$

where ACCP represents the accelerator position, TE is the target torque, K is a peak gain of the target torque with respect to the change in the accelerator position, ω is a time constant of the phase advance compensation and s is a Laplace operator.

3. The engine control unit (10) as claimed in claim 3, further comprising
rotation speed sensing means (21) for sensing the engine rotation speed; and
control gain changing means for changing the peak gain continuously or stepwise in accordance with the engine rotation speed.
4. The engine control unit (10) as claimed in claim 2 or 3, comprising
rotation speed sensing means (21) for sensing the engine rotation speed; and
response time constant changing means for changing the time constant continuously or stepwise in accordance with the engine rotation speed.
5. The engine control unit (10) as claimed in one of claims 1 to 4,
rotation speed sensing means (21) for sensing the engine rotation speed;
injection quantity setting means (S3, S4) for calculating the fuel injection quantity in accordance with the target torque;
injection pressure setting means (S5) for calculating a fuel injection pressure in accordance with the fuel injection quantity and the engine rotation speed; and
injection timing setting means (S6) for calculating injection start timing in accordance with the fuel injection quantity and the engine rotation speed.
6. The engine control unit (10) as claimed in one of claims 1 to 4, comprising
rotation speed sensing means (21) for sensing the engine rotation speed;
injection ratio controlling means for performing a multi-step injection for injecting the fuel in multiple times by driving a fuel injection device, which injects the high-pressure fuel into the cylinder of the engine, multiple times in a combustion stroke of the engine (1); and
injection number setting means for calculating the number of the injections performed in the multi-step injection in accordance with the engine rotation speed.

Patentansprüche

1. Maschinensteuerungseinheit (10) mit

einer Beschleunigerpositionserfassungseinrichtung (22) zum Erfassen einer Beschleunigerposition, die einem Betätigungsgrad eines Beschleunigers durch eine Bedienperson entspricht, einer Solldrehmomenteinstellungseinrichtung (S2) zum Berechnen eines Solldrehmoments einer Maschine (1) basierend auf der Beschleunigerposition, und einer Einspritzmengeneinstellungseinrichtung (S3, S4) zum Berechnen einer Kraftstoffeinspritzmenge (QFIN) von Kraftstoff, die in einen Zylinder der Maschine (1) eingespritzt wird, gemäß dem Solldrehmoment, wobei die Maschinensteuerungseinheit (10) das Maschinendrehmoment oder die Maschinendrehzahl durch ein Ändern der Kraftstoffeinspritzmenge (QFIN) steuert, und wobei die Solldrehmomenteinstellungseinrichtung (S2) eine Phasenvoreilkomensationseinrichtung (26) zum Einstellen einer Antwort des berechneten Solldrehmoments in einer Übergangszeitspanne, in der sich die Beschleunigerposition ändert, umfasst,

dadurch gekennzeichnet, dass

die Phasenvoreilkomensationseinrichtung (26) eine Übertragungsfunktion berechnet, die die folgende Gleichung erfüllt:

$$TE = \{(Ks + \omega)/(s + \omega)\} \cdot ACCP,$$

wobei ACCP die Beschleunigerposition darstellt, TE das Solldrehmoment ist, K eine maximale Verstärkung des Solldrehmoments in Bezug auf die Änderung der Beschleunigerposition ist, ω eine Zeitkonstante der Phasenvoreilkomensation ist und s ein Laplace-Operator ist, wobei durch das Einstellen der Zeitkonstante (ω) eine Konvergenzzeit für das Solldrehmoment (TE) festgelegt wird, um sich von einem maximalen Wert, der der maximalen Verstärkung (K) entspricht, zu einem Solldrehmomentpunkt zu ändern, der sich nach der Änderung der Beschleunigerposition (ACCP) mit der Maschinendrehzahl (NE) statisch im Gleichgewicht befindet.

2. Maschinensteuerungseinheit (10) gemäß Anspruch 1, wobei

die Phasenvoreilkomensationseinrichtung (26) eine Übertragungsfunktion berechnet, die eine folgende Gleichung erfüllt:

$$TE = \{(Ks + \omega)/(s + \omega)\} \cdot ACCP,$$

wobei ACCP die Beschleunigerposition darstellt, TE das Solldrehmoment ist, K eine maximale Verstärkung des Solldrehmoments in Bezug auf die Änderung der Beschleunigerposition ist, ω eine Zeitkonstante der Phasenvoreilkomensation ist und s ein Laplace-Operator ist.

3. Maschinensteuerungseinheit (10) gemäß Anspruch 2, des Weiteren mit

einer Drehzahlerfassungseinrichtung (21) zum Erfassen der Maschinendrehzahl; und einer Steuerungsverstärkungsänderungseinrichtung zum fortlaufenden oder stufenweisen Ändern der maximalen Verstärkung gemäß der Maschinendrehzahl.

4. Maschinensteuerungseinheit (10) gemäß Anspruch 2 oder 3, mit

einer Drehzahlerfassungseinrichtung (21) zum Erfassen der Maschinendrehzahl; und einer Antwortzeitkonstantenänderungseinrichtung zum fortlaufenden oder stufenweisen Ändern der Zeitkonstanten gemäß der Maschinendrehzahl.

5. Maschinensteuerungseinheit (10) gemäß einem der Ansprüche 1 bis 4, mit

einer Drehzahlerfassungseinrichtung (21) zum Erfassen der Maschinendrehzahl;
 einer Einspritzmengeneinstellungseinrichtung (S3, S4) zum Berechnen der Kraftstoffeinspritzmenge gemäß dem Solldrehmoment;
 einer Einspritzdruckeinstellungseinrichtung (S5) zum Berechnen eines Kraftstoffeinspritzdrucks gemäß der Kraftstoffeinspritzmenge und dem Maschinendrehzahl; und
 einer Einspritzzeitabstimmungseinrichtung (S6) zum Berechnen einer Kraftstoffeinspritzstartzeitabstimmung gemäß der Kraftstoffeinspritzmenge und der Maschinendrehzahl.

6. Maschinensteuerungseinheit (10) gemäß einem der Ansprüche 1 bis 4, mit

einer Drehzahlerfassungseinrichtung (21) zum Erfassen der Maschinendrehzahl;
 einer Einspritzverhältnissteuerungseinrichtung zum Durchführen einer mehrstufigen Einspritzung, um den Kraftstoff in mehreren Malen durch Antreiben einer Kraftstoffeinspritzvorrichtung, die den Hochdruckkraftstoff in den Zylinder der Maschine einspritzt, mehrere Male in einem Verbrennungstakt der Maschine (1) einzuspritzen; und
 einer Einspritzanzahleinstellungseinrichtung zum Berechnen der Anzahl von den Einspritzungen, die gemäß der Maschinendrehzahl in der mehrstufigen Einspritzung durchgeführt werden.

Revendications

1. Unité de commande de moteur (10) incluant un moyen de détection de position d'accélérateur (22) pour la détection d'une position d'accélérateur correspondant à un degré de fonctionnement d'un accélérateur par un opérateur, un moyen de définition de couple cible (S2) pour le calcul d'un couple cible d'un moteur (1) sur la base de la position d'accélérateur, et un moyen de définition de quantité d'injection (S3, S4) pour calculer une quantité d'injection de combustible (QFIN) de combustible injecté dans un cylindre du moteur (1) selon le couple cible, dans laquelle l'unité de commande de moteur (10) commande le couple de moteur ou la vitesse de rotation de moteur en changeant la quantité d'injection de combustible (QFIN) et dans laquelle le moyen de définition de couple cible (S2) inclut un moyen de compensation d'avance de phase (26) pour la définition d'une réponse du couple cible calculé dans une période de transition, dans laquelle la partie d'accélérateur change,
- caractérisée en ce que**
 le moyen de compensation d'avance de phase (26) calcule une fonction de transfert qui satisfait à l'équation suivante :

$$TE = \{(Ks + \phi) / (s + \phi)\} \bullet ACCP,$$

où ACCP représente la position d'accélérateur, TE est le couple cible, K est un gain de crête du couple cible par rapport au changement de position d'accélérateur, ϕ est une constante de temps de la compensation d'avance de phase et s est un opérateur Laplace, dans laquelle par la définition de la constante de temps (ϕ), un temps de convergence est défini pour le couple cible (TE) pour passer d'une valeur de crête correspondant au gain de crête (K) à un point de couple cible, qui est statiquement compensé par la vitesse de rotation de moteur (NE) après le changement de position d'accélérateur (ACCP).

2. Unité de commande de moteur (10) selon la revendication 1, dans laquelle le moyen de compensation d'avance de phase (26) calcule une fonction de transfert qui satisfait à une équation suivante :

$$TE = \{(Ks + \phi) / (s + \phi)\} \bullet ACCP,$$

où ACCP représente la position d'accélérateur, TE est le couple cible, K est un gain de crête du couple cible par rapport au changement de position d'accélérateur, ϕ est une constante de temps de la compensation d'avance de phase et s est un opérateur Laplace.

3. Unité de commande de moteur (10) selon la revendication 3, comprenant en outre un moyen de détection de vitesse de rotation (21) pour détecter la vitesse de rotation de moteur ; et un moyen de changement de gain de commande pour changer le gain de crête en continu ou par étapes selon la

vitesse de rotation de moteur.

4. Unité de commande de moteur (10) selon la revendication 2 ou 3, comprenant un moyen de détection de vitesse de rotation (21) pour détecter la vitesse de rotation de moteur ; et
un moyen de changement de constante de temps de réponse pour changer la constante de temps en continu ou par étapes selon la vitesse de rotation de moteur.
5. Unité de commande de moteur (10) selon l'une quelconque des revendications 1 à 4, comprenant
un moyen de détection de vitesse de rotation (21) pour détecter la vitesse de rotation de moteur ;
un moyen de définition de quantité d'injection (S3, S4) pour calculer la quantité d'injection de combustible selon le couple cible ;
un moyen de définition de pression d'injection (S5) pour calculer une pression d'injection de combustible selon la quantité d'injection de combustible et la vitesse de rotation de moteur ; et
un moyen de définition de minutage d'injection (S6) pour calculer un minutage de démarrage d'injection selon la quantité d'injection de combustible et la vitesse de rotation de moteur.
6. Unité de commande de moteur (10) selon l'une quelconque des revendications 1 à 4, comprenant
un moyen de détection de vitesse de rotation (21) pour détecter la vitesse de rotation de moteur ; et
un moyen de commande de rapport d'injection pour réaliser une injection multi-étapes pour injecter le combustible de multiples fois par l'entraînement d'un dispositif d'injection de combustible, qui injecte le combustible haute pression dans le cylindre du moteur, de multiples fois dans une course de combustion du moteur (1) ; et
un moyen de définition de nombre d'injection pour calculer le nombre d'injections réalisées dans l'injection multi-étapes selon la vitesse de rotation de moteur.

FIG. 1

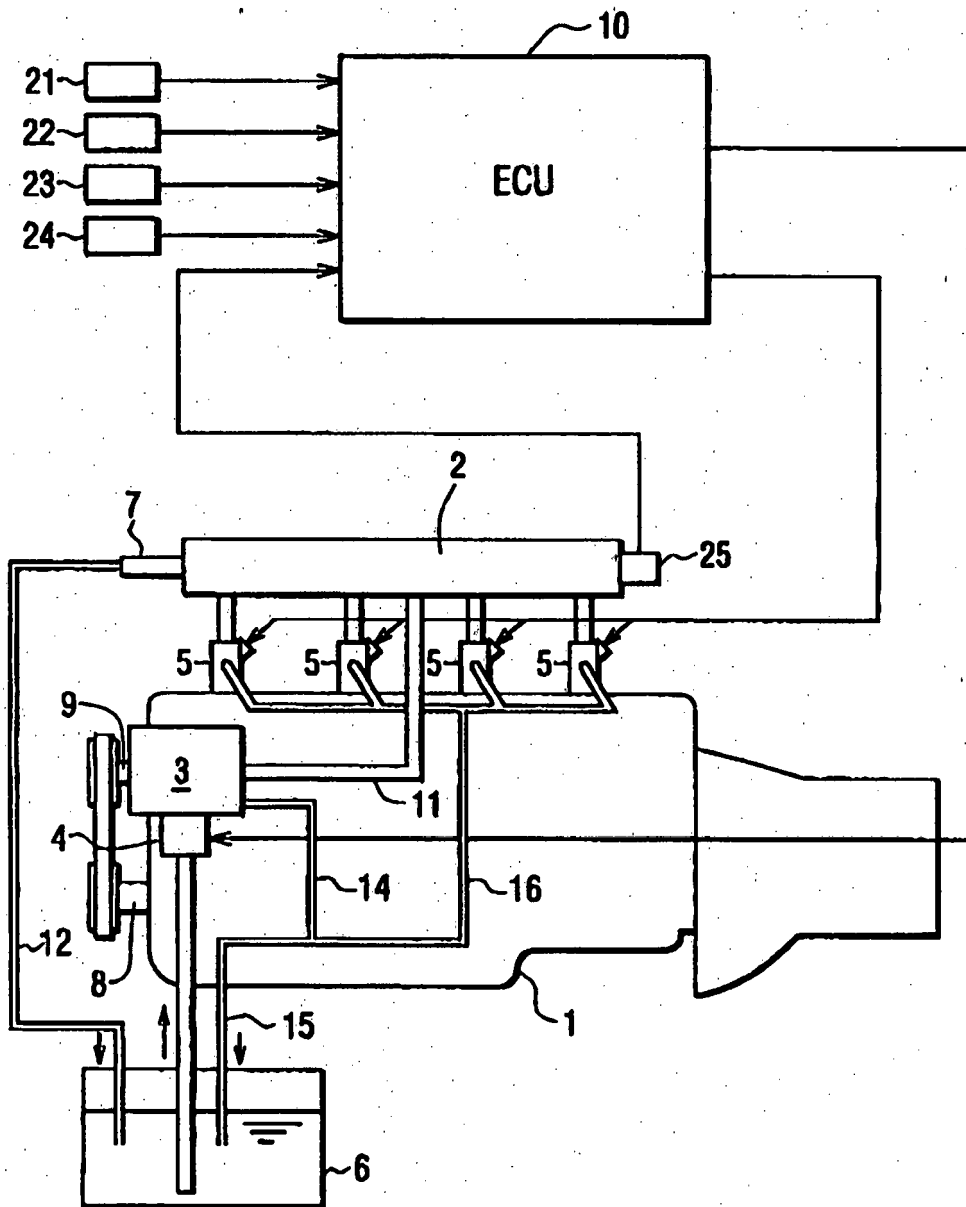


FIG. 2

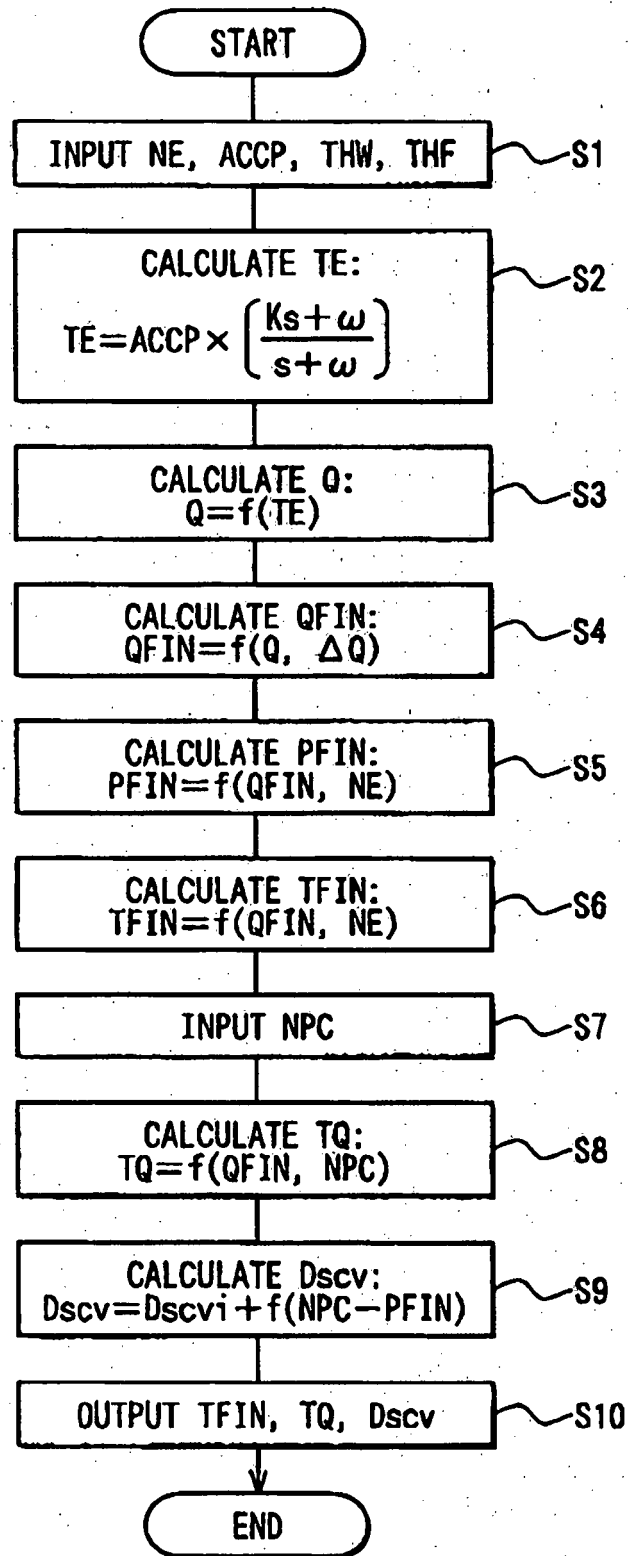


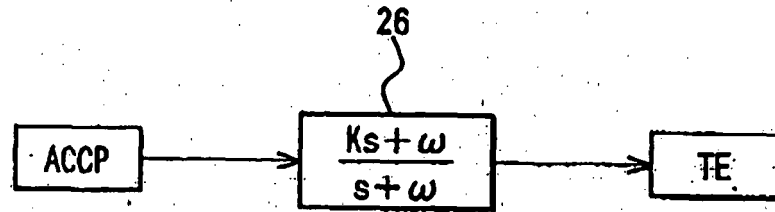
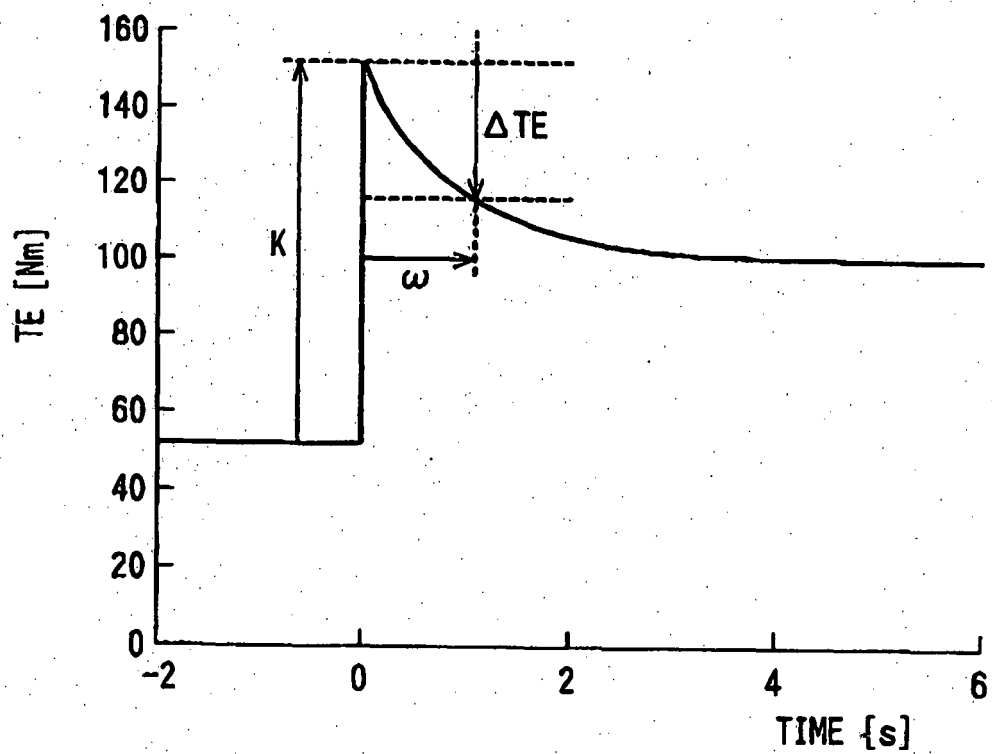
FIG. 3 (a)**FIG. 3 (b)**

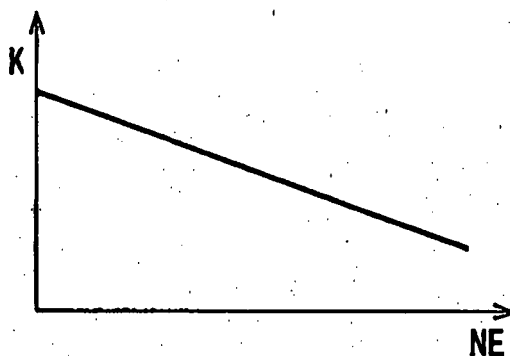
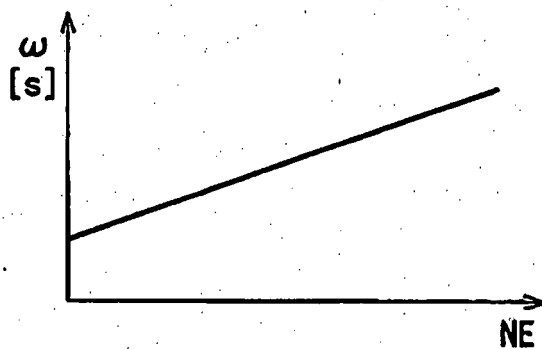
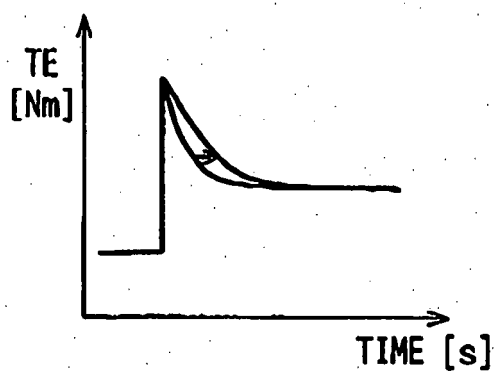
FIG. 4 (a)**FIG. 4 (b)****FIG. 4 (c)**

FIG. 5

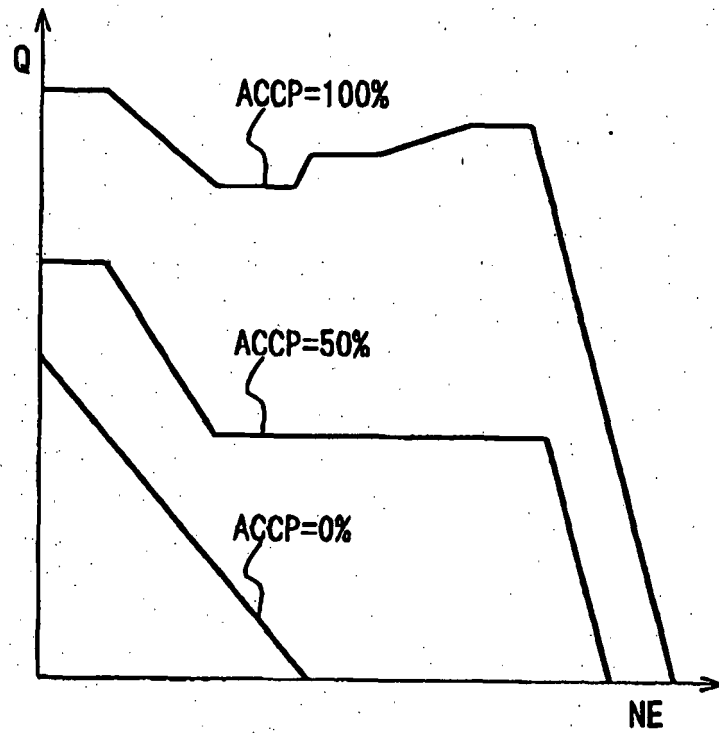
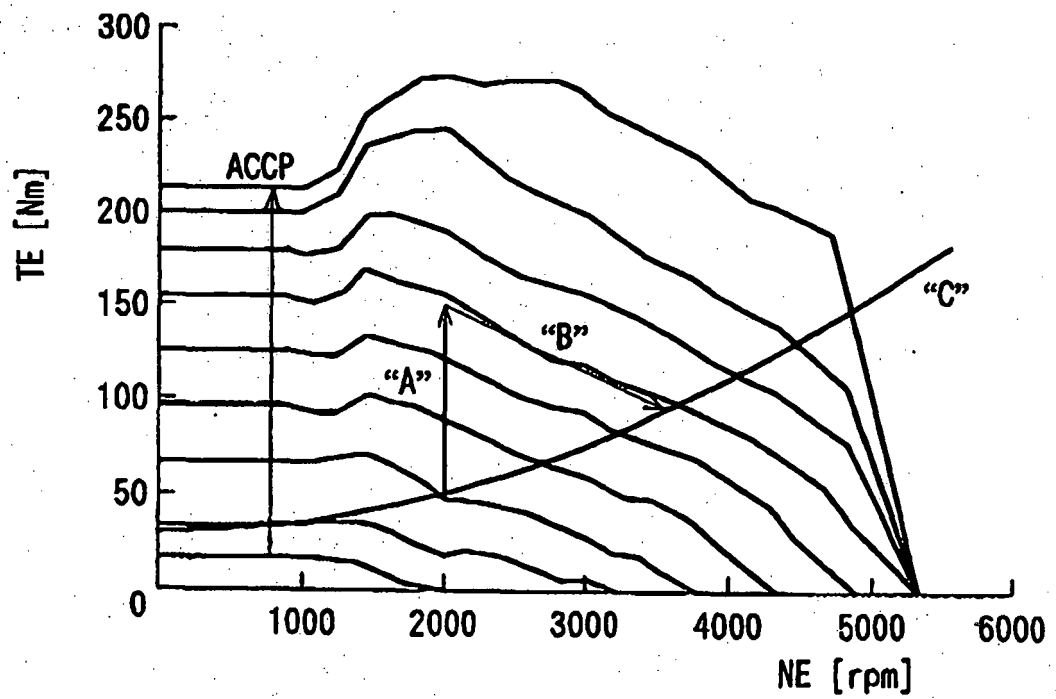


FIG. 6



REFERENCES CITED IN THE DESCRIPTION

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