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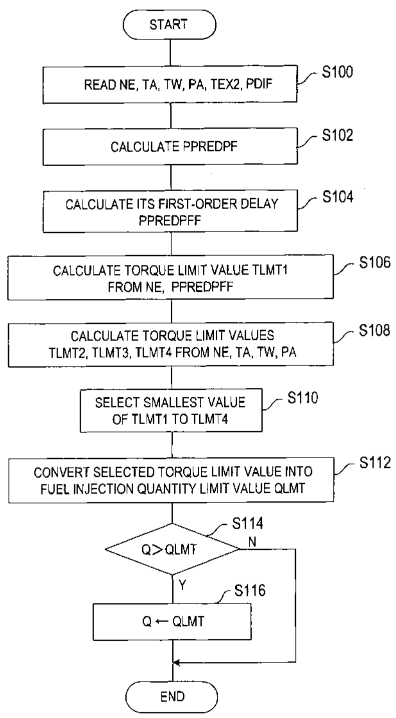
(54) Engine output control system for internal combustion engine

(57) In an engine output control system, the exhaust gas pressure PPREDPF immediately before the DPF (filter) that captures particulates entrained by the exhaust gas is detected (S100 to S104), the engine output upper limit value (TLMT1) is calculated so that the upper limit value decreases with increasing exhaust gas pressure (S106), and the engine output is controlled based on the calculated upper limit value (S108 to S116). Thus, by ascertaining rise in the temperature and pressure of the exhaust system owing to clogging of the DPF virtually directly and restricting the output of the engine accordingly, excessive exhaust temperature increase can be avoided, thereby preventing degradation of exhaust system components, and excessive exhaust gas pressure increase can be avoided, thereby inhibiting exhaust gas leakage from exhaust system component joints with high reliability.

FIG. 3



Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to an engine output control system for an internal combustion engine, particularly to an engine output control system for use in an internal combustion engine equipped with a diesel particulate filter (DPF) for capturing particulates or particulate matter.

Description of the Related Art

[0002] The exhaust system of a diesel engine is equipped with a DPF that removes fine particulate matter from the exhaust gas by capturing them in microporous trap. As the buildup of captured fine particulate matter increases, the DPF progressively clogs. Therefore, as taught by Japanese Laid-Open Patent Application 2004-108207, one practice is to estimate the buildup of captured particulates from the differential pressure across the DPF and regenerate the DPF by burning the particles, i.e., by conducting oxidation removal when the estimated value is equal to or exceeds a prescribed value.

[0003] When the buildup of particulates approaches its limit, the differential pressure across the DPF increases greatly. This accelerates degradation of the DPF and lowers fuel economy by increasing the pressure of the exhaust gas. The prior art addresses this problem by limiting the maximum fuel injection quantity when the buildup of captured particulates is equal to or exceeds a predetermined value, thereby avoiding a great increase in exhaust gas quantity or flow rate and preventing degradation of the DPF.

[0004] DPF clogging is caused not only by particulates but also by ash (that is combustion remnants of oil metal components and the like). The ash captured by the DPF cannot be removed by burning, so degradation of the DPF proceeds gradually owing to ash buildup even if the particulates are removed.

[0005] A DPF thus clogs with the increasing buildup of captured particulates and ash. Clogging of the DPF raises the exhaust gas pressure and lowers the exhaust gas flow velocity. The temperature of the exhaust system therefore rises to accelerate exhaust system component degradation and the pressure thereof rises to increase the likelihood of exhaust gas leakage from the exhaust system component joints.

[0006] The teaching of the prior art is to prevent DPF degradation by determining the best time for regeneration from the differential pressure across the DPF and limiting the fuel injection quantity during regeneration. However, detection of exhaust system conditions based solely on the differential pressure across the DPF does not enable accurate discernment of the temperature rise and pressure increase produce in the exhaust system by DPF clogging. The prior art therefore cannot adequately alleviate the foregoing problems of component degradation and exhaust gas leakage.

SUMMARY OF THE INVENTION

[0007] An object of this invention is therefore to overcome the foregoing drawback by providing an engine output control system for an internal combustion engine that virtually directly ascertains increase in exhaust system temperature and pressure owing to DPF (filter) clogging and restricts engine output accordingly, thereby reliably preventing degradation of exhaust system components owing to excessive increase in exhaust system temperature and reliably inhibiting exhaust gas leakage from exhaust system component joints owing to excessive increase in exhaust gas pressure.

[0008] In order to achieve the object, this invention provides a system for controlling an output of an internal combustion engine having a filter installed in an exhaust system for capturing particulates entrained by an exhaust gas produced by the engine, characterized by: exhaust pressure detecting means for detecting an exhaust gas pressure before the filter; engine output upper limit value calculating means for calculating an upper limit value of the output of the engine based on the detected exhaust gas pressure such that the upper limit value decrease as the exhaust gas pressure increases; and engine output controlling means for controlling the output of the engine based on the calculated upper limit value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The above and other objects and advantages of the invention will be more apparent from the following description and drawings in which:

FIG. 1 is a schematic drawing showing the overall configuration of an engine output control system for an internal combustion engine according to a first embodiment of the invention;

FIG. 2 is a flowchart showing the part of the operation of the system shown in FIG. 1 that relates to calculation of a fuel injection quantity;

FIG. 3 is a flowchart showing the part of the operation of the system shown in FIG. 1 that relates to restricting the output of an internal combustion engine;

FIG 4 is a graph for explaining the characteristics of a torque limit value (upper limit value of the output of the engine), which is used in the flowchart of FIG. 3;

FIG. 5 is a flowchart similar to FIG. 3 showing the operation of an engine output control system for an internal combustion engine according to a second embodiment of this invention; and

FIG. 6 is a graph for explaining the characteristics of a torque (output) demand TCUR used in the flowchart of FIG. 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] An engine output control system for an internal combustion engine according to embodiments of the present invention will now be explained with reference to the attached drawings.

[0011] FIG. 1 is a schematic drawing showing the overall configuration of the engine output control system for an internal combustion engine according to a first embodiment of the invention.

[0012] The reference numeral 10 in FIG. 1 designates a four-cylinder internal combustion engine, more specifically diesel engine (compression-ignition engine) and the reference numeral 10a designates the main unit of the engine 10. Intake air sucked in through an air cleaner 12 of the engine 10 flows through an air intake pipe (air intake passage) 14.

[0013] An intake shutter or intake air throttle 16 is installed at a suitable point in the intake pipe 14. The intake shutter 16 includes a valve 16a and an electric motor or other actuator 16b connected to the valve 16a. When the actuator 16b of the intake shutter 16 is driven by a drive circuit (not shown) to rotate the valve 16a in the closing direction, the opening of the intake pipe 14 is reduced to reduce the flow rate of intake air through the intake pipe 14.

[0014] The air flowing through the intake pipe 14 passes through an intake manifold 20 installed downstream of the intake shutter 16 and arrives at the individual cylinders to be drawn into their combustion chambers (not shown) when the associated intake valve (not shown) opens and the associated piston (not shown) descends. The inspired air is compressed and reaches a high temperature when the piston ascends.

[0015] Fuel (kerosene) stored in a fuel tank (not shown) is supplied through a pump and a common rail (neither shown) to fuel injectors 22 (only one shown) directed into the combustion chambers of the individual cylinders. When each fuel injector 22 is driven through a drive circuit (not shown), it injects fuel into the associated combustion chamber and the injected fuel spontaneously ignites and bums upon coming in contact with the compressed, high-temperature intake air. As a result, the piston is first driven downward and thereafter ascends to discharge the exhaust gas into an exhaust manifold 24 (of the exhaust system) upon opening of an associated exhaust valve (not shown). The exhaust gas then flows into a downstream exhaust pipe 26 (of the exhaust system).

[0016] An EGR pipe (Exhaust Gas Recirculation passage) 30 connected to the intake pipe 14 at one end is connected to the exhaust pipe 26 at the other end. The EGR pipe 30 is equipped with an EGR valve 30a. When the EGR valve 30a is operated through a drive circuit (not shown), the EGR pipe 30 is opened to return part of the exhaust gas to the air intake system.

[0017] The turbine (not shown) of a turbocharger (illustrated as "T/C") 32 is installed in the exhaust pipe 26 at a location downstream of the point at which the EGR pipe 30 is connected. The turbine is rotated by the exhaust gas to drive a compressor 32a through a mechanical interconnection, thereby supercharging the engine 10 with intake air from the air cleaner 12.

[0018] An oxidation catalytic converter (illustrated as "CAT") 34 utilizing platinum or the like as catalyst is installed in the exhaust pipe 26 downstream of the turbocharger 32. The oxidation catalytic converter 34 oxidizes and removes unburned hydrocarbons in the exhaust gas. The oxidization conducted in the oxidation catalytic converter 34 increases the exhaust gas temperature.

[0019] A DPF (Diesel Particulate Filter) 36 is installed downstream of the oxidation catalytic converter 34 for capturing particulates entrained by the exhaust gas. The DPF 36 comprises a ceramic honeycomb filter internally provided with exhaust gas passages whose upstream ends are closed and downstream ends are opened arranged alternately with exhaust gas passages whose upstream ends are opened and downstream ends are closed. Microporous walls formed with numerous holes of around 10 μm diameter are provided between adjacent passages. Particulates contained in the exhaust gas are captured in these holes.

[0020] The DPF 36 experiences clogging owing to gradual buildup of the so-captured particulates. In this embodiment, the DPF 36 is a catalyzed soot filter (CSF) in which the temperature at which the particulates can be burned is reduced by the action of a catalyst carried on the filter and the particulates captured from the exhaust gas are burned at the reduced temperature.

[0021] In addition to the particulates, ash (combustion remnants of oil metal components and the like) is also contained in the exhaust gas and captured by the DPF 36. Since the ash captured and built up in the DPF 36 cannot be removed by burning, so degradation of the DPF 36 proceeds gradually owing to ash buildup even if the particulates are completely removed.

[0022] After passing through the DPF 36, the exhaust gas passes through a silencer, tailpipe and the like (none of which are shown) to be discharged to outside the engine 10.

[0023] A crank angle sensor 40 including multiple sets of magnetic pickups is installed near the crankshaft (not shown) of the engine 10. The crank angle sensor 40 produces outputs indicative of a cylinder identification signal, a TDC signal at or near the TDC of each of the four cylinders, and a crank angle signal every prescribed crank angle.

[0024] A coolant temperature sensor 42 installed near a coolant passage (not shown) of the engine 10 produces an output or signal indicative of the engine coolant temperature TW. An airflow meter 44 equipped with a temperature detection element is installed in the intake pipe 14 at a point near the air cleaner 12. The airflow meter 44 produces outputs or signals indicative of the flow rate of (intake) air sucked through the air cleaner 12 indicative of the engine load and the temperature TA thereof (the intake air temperature or outside air temperature).

[0025] An accelerator position sensor 50 is installed near an accelerator pedal 46 located on the floor near the driver's seat (not shown) of the vehicle in which the engine 10 is installed. The accelerator position sensor 50 produces an output or signal indicative of the accelerator position or opening θAP, which is indicative of the engine load. A wheel speed sensor 52 installed at a suitable part of a wheel (not shown) produces an output or signal every predetermined angle of rotation of the wheel indicative of a travel speed of the vehicle.

[0026] A first exhaust gas temperature sensor 54 is installed in the exhaust system of the engine 10 at a suitable location downstream of the turbocharger 32 and upstream of the oxidation catalytic converter 34. The first exhaust gas temperature sensor 54 produces an output indicative of the exhaust gas temperature TEX1 on the upstream side of the oxidation catalytic converter 34 (temperature of the exhaust gas flowing into the oxidation catalytic converter 34). A second exhaust gas temperature sensor 56 is installed downstream of the oxidation catalytic converter 34 and upstream of the DPF 36 (immediately before the DPF 36). The second exhaust gas temperature sensor 56 produces an output indicative of the exhaust gas temperature TEX2 on the upstream side of the DPF 36 (temperature of the exhaust gas flowing into the DPF 36).

[0027] The DPF 36 is provided with a differential pressure sensor 60 that produces an output indicative of the differential pressure PDIF between the pressure of the exhaust gas flowing into the DPF 36 and the pressure of the exhaust gas flowing out of the DPF 36, i.e., the differential pressure PDIF between the inlet side and outlet side pressures of the DPF 36.

[0028] The outputs of the foregoing sensors are sent to an ECU (Electronic Control Unit) 62. The ECU 62 is constituted as a microcomputer comprising a CPU, ROM, RAM and input/output circuit. The ECU 62 detects or calculates the engine speed NE of the engine 10 by using a counter to count the crank angle signals outputted by the crank angle sensor 40 and detects or calculates the vehicle speed by using a counter to count the signals outputted by the wheel speed sensor 52.

[0029] The ECU 62 is housed in a case (not shown) and installed at an appropriate location near the driver's seat of the vehicle. An atmospheric pressure sensor 64 accommodated in the case sends the ECU 62 an output indicative of the atmospheric pressure PA at the current location of the engine 10.

[0030] The operation of the engine output control system shown in FIG. 1 will now be explained.

[0031] FIG. 2 is a flowchart showing the part of the operation that relates to calculation of the fuel injection quantity Q. The routine of FIG. 2 is executed in the ECU 62 at or near the TDC (Top Dead Center) of every cylinder.

[0032] In S10, the accelerator position θAP and other operating parameters detected by the aforesaid sensors are read. The program then goes to S12, in which the detected accelerator position θAP is used to calculate a basic fuel injection quantity by retrieval from a table stored in ROM, to S 14, in which a correction quantity for correcting the calculated basic fuel injection quantity is calculated based on the other engine operating parameters, to S16, in which the fuel injection quantity Q is calculated based on the calculated basic fuel injection quantity and its correction quantity, and to S18, in which the quantity of fuel indicated by the calculated fuel injection quantity Q is injected through the injector 22 at an appropriate fuel injection time point, thereby controlling the engine output.

[0033] FIG. 3 is a flowchart showing the part of the operation of the system of FIG. 1 that relates to restricting the output of the engine 10. The routine of FIG. 3 is executed in the ECU 62 at predetermined time intervals, e.g., every 20 milliseconds.

[0034] In S100, the engine speed NE, intake air temperature TA, engine coolant temperature TW, atmospheric pressure PA, exhaust gas temperature TEX2 and differential pressure PDIF detected by the sensors are read.

[0035] Next, in S102, the exhaust gas pressure PPREDPF immediately before the DPF 36 is calculated as an absolute pressure (in other words, the exhaust gas pressure PPREDPF immediately before the DPF 36 is indirectly detected as an absolute pressure). Specifically, the exhaust gas pressure PPREDPF is calculated based on the detected differential pressure PDIF, exhaust gas temperature TEX2 and engine speed NE, and the fuel injection quantity Q calculated by the routine of FIG. 2.

[0036] More specifically, the exhaust gas pressure PPREDPF is determined by calculating the pressure loss of the DPF 36 from the detected differential pressure PDIF and then calculating the pressure loss downstream of the DPF 36 (from the DPF 36 to the tailpipe, mainly the silencer).

[0037] In other words, the exhaust gas flow rate is calculated from the detected engine speed NE and the intake air flow rate in accordance with a suitable characteristic curve. Next, the calculated exhaust gas flow rate and the detected exhaust gas temperature TEX2 (more exactly, the internal temperature of the DPF 36 estimated from the exhaust gas temperature TEX2) are used to retrieve a value from a map of experimentally obtained values stored in the ROM beforehand, and the retrieved value is defined or calculated as the pressure loss downstream of the DPF 36. The mapped pressure loss is defined or determined to increase as the exhaust gas flow rate and exhaust gas temperature TEX2 (more exactly, the internal temperature of the DPF 36 estimated from the exhaust gas temperature TEX2) increase.

[0038] The region downstream of tailpipe is the open air outside the engine 10 and is the atmospheric pressure PA. The value obtained by calculating the two pressure losses and adding them together will therefore be the exhaust gas pressure PPREDPF immediately before the DPF 36.

[0039] Instead of indirect detection by such a calculation, it is also possible, as indicated by the phantom line in FIG 1, to install at a location upstream of the DPF 36 a pressure sensor 66 that produces an output indicative of the pressure at this point as an absolute pressure and directly detect the exhaust gas pressure PPREDPF immediately before the DPF 36 from the output of the sensor 66.

[0040] Next, in S104, an appropriate filter (mathematic equation) is used to calculate the first-order delay PPREDPFF of the calculated (or detected) exhaust gas pressure PPREDPF. This is for removing noise.

[0041] Next, in S 106, the detected engine speed NE and the calculated exhaust gas pressure first-order delay PPREDPFF are used to calculate a torque limit value (indicative of upper limit value of the output of the engine 10) TLMT1 by retrieval from a map of experimentally obtained values stored in the ROM beforehand.

[0042] FIG. 4 is a graph for explaining the characteristic of the map. It will be noted that the torque limit value TLMT1 is defined or determined to decrease with increasing exhaust gas pressure first-order delay PPREDPFF. More exactly, it decreases with increasing exhaust gas pressure first-order delay PPREDPFF and engine speed NE.

[0043] The reason for this is that the temperature of the exhaust system rises as the exhaust gas pressure first-order delay PPREDPFF increases and the exhaust gas flow rate per unit time increases as the engine speed NE increases, thereby also raising the temperature of the exhaust system, so the output of the engine 10 is restricted in response to these increases in order to prevent further increase in the temperature of the exhaust system.

[0044] The torque limit value TLMT1 is defined or determined to decrease sharply in the vicinity of the broken line a. In the experience of the inventors, the likelihood of exhaust gas leakage from exhaust system component joints (e.g., from the joint between the exhaust manifold 24 and exhaust pipe 26) becomes high when the exhaust gas pressure rises to around this level (e.g., 2,000 hPa). The torque limit value TLMT1 is therefore defined or determined to decrease sharply when the exhaust gas pressure (more exactly, its first-order delay PPREDPFF) approaches the broken line a.

[0045] Next, in S108, a torque limit value TLMT2 for avoiding overspeeding of the engine 10, a torque limit value TLMT3 for avoiding overheating of the engine 10, and a torque limit value TLMT4 for high-elevation compensation are calculated based on the detected engine speed NE, intake air temperature TA, engine coolant temperature TW and atmospheric pressure PA, in accordance with appropriate characteristics.

[0046] Next, in S110, the one of the four calculated torque limit values TLMT1, TLMT2, TLMT3 and TLMT4 having the smallest value is selected, and to S 112, in which the selected torque limit value is converted into a fuel injection quantity limit value QLMT (indicative of the upper limit value of the output of the engine 10) in accordance with an appropriate characteristic.

[0047] Next, in S114, it is determined whether the fuel injection quantity Q calculated by the routine of FIG. 2 is greater than the converted fuel injection quantity limit value QLMT. When the result is YES, the program goes to S 116, in which the calculated fuel injection quantity Q is replaced by the fuel injection quantity limit value QLMT (i.e., the fuel injection quantity Q is made the fuel injection quantity limit value QLMT). When the result in S114 is NO, S 116 is skipped.

[0048] As mentioned above, fuel is injected in S 18 of the flowchart of FIG. 2 at an appropriate time point based on the calculated fuel injection quantity Q. In other words, the output or torque of the engine 10 is controlled. At this time, If the torque limit value TLMT1 is selected as the smallest value and the value TLMT1 is converted into the fuel injection quantity limit value QLMT, the fuel injection quantity is determined to be not greater than this fuel injection quantity limit value and fuel injection is conducted based thereon (i.e., the output of the engine 10 is controlled based on the converted upper limit value of the output).

[0049] This embodiment is thus configured to have a system for controlling an output of an internal combustion engine (10) having a filter (DPF 36) installed in an exhaust system (exhaust manifold 24, exhaust pipe 26) for capturing particulates entrained by an exhaust gas produced by the engine, characterized by: exhaust pressure detecting means (ECU 62, S 100 to S104) for detecting an exhaust gas pressure before the filter PPREDPF, more specifically for detecting a first-order delay of an exhaust gas pressure before the filter PPREDPFF; engine output upper limit value calculating means (ECU 62, S106) for calculating an upper limit value (TLMT1) of the output of the engine (10) based on the detected exhaust gas pressure such that the upper limit value (TLMT1) decreases as the exhaust gas pressure increases; and engine output controlling means (ECU 62, S108 to S 116, S 18) for controlling the output of the engine based on the calculated upper limit value (TLMT1).

[0050] Thus, this embodiment is configured to detect the exhaust gas pressure PPREDPF immediately before the DPF (filter) that captures particulates entrained by the exhaust gas, calculate the upper limit value (TLMT1) of the output of the engine 10 as a function of at least the detected exhaust gas pressure so that the upper limit value decreases with increasing exhaust gas pressure, and control the output of the engine 10 based on the calculated upper limit value of the output. In other words, it is configured to ascertain rise in the temperature and pressure of the exhaust system owing to clogging of the DPF 36 virtually directly and restrict the output of the engine 10 accordingly. Owing to this configuration, excessive temperature increase of the exhaust system can be avoided, thereby preventing degradation of exhaust system components with high reliability, and excessive increase in exhaust gas pressure can be avoided, thereby inhibiting exhaust gas leakage from exhaust system component joints (e.g., from the joint between the exhaust manifold 24 and exhaust pipe 26) with high reliability.

[0051] Specifically, the engine output control system is configured so that the upper limit value of the output of the engine 10 is calculated to decrease gradually with increasing exhaust gas pressure. Therefore, excessive rise in the temperature of the exhaust system and excessive rise in the exhaust gas pressure can be reliably prevented while keeping the restriction of the output of the engine 10 to the minimum required. Thus the output of the engine 10 is restricted in proportion to increase in the exhaust gas pressure because the temperature of the exhaust system also increases along with the pressure increase. This makes it possible to prevent further increase in the temperature and pressure of the exhaust system, with high reliability and without lowering the output of the engine 10 more than necessary. Therefore, reliable prevention of exhaust system component degradation owing to excessive increase in exhaust gas temperature and reliable inhibition of exhaust gas leakage from exhaust system component joints owing to excessive increase in exhaust gas pressure can both be achieved while keeping the restriction on the output of the engine 10 to the minimum required.

[0052] Moreover, the output control system comprises engine speed detection means (the crank angle sensor 40 and ECU 62) for detecting the engine speed NE of the engine 10 and the engine output upper limit value calculating means is configured to calculate the upper limit value of the output so as to decrease with increase of the exhaust gas pressure PPREDPF and engine speed NE (ECU 62, S106).

[0053] Thus the engine output control system is in this manner configured to calculate the upper limit value of the output of the engine 10 so as to decrease with increase of the exhaust gas pressure and engine speed NE. Therefore, further rise in the temperature of the exhaust system and rise in the exhaust gas pressure can be still more reliably prevented while keeping the restriction of the output of the engine 10 to the minimum required. Thus the output of the engine 10 is restricted in proportion to increase in the exhaust gas pressure and increase in the engine speed NE because the temperature of the exhaust system increases along with the pressure increase and also increases along with increase in exhaust gas flow rate per unit time as the engine speed NE increases. This makes it possible to prevent further increase in the temperature and pressure of the exhaust system, with high reliability and without lowering the output of the engine 10 more than necessary. Therefore, reliable prevention of exhaust system component degradation owing to excessive increase in exhaust gas temperature and reliable inhibition of exhaust gas leakage from exhaust system component joints owing to excessive increase in exhaust gas pressure can both be achieved while keeping the restriction on the output of the engine 10 to the minimum required.

[0054] FIG. 5 is a flowchart similar to the flowchart of FIG. 3 showing the operation of an engine output control system for an internal combustion engine according to a second embodiment of this invention.

[0055] The processing performed in S 100 to S 116 in the second embodiment is the same as that in the corresponding steps of the first embodiment.

[0056] Upon completion of this processing, the routine of FIG. 5 goes to S 118, in which the engine speed NE is used to calculate the torque or output TCUR required by the engine 10 by retrieval from a table of experimentally obtained values stored in ROM beforehand.

[0057] FIG. 6 is a graph for explaining the characteristic of the table. As the buildup of particulates and ash proceeds, the torque limit value TLMT1 calculated by the processing in S 100 to S 116 gradually decreases so that the upper limit of the fuel injection quantity also decreases gradually. The maximum output torque of the engine 10 therefore gradually decreases. As a result, the maximum output torque of the engine 10 may come to fall below the required torque or output TCUR.

[0058] This required torque or output TCUR is the torque or output necessary to make the engine 10 an appealing product from the perspective of the user. It is undesirable for the output torque of the engine 10 to fall below the required torque TCUR because this means that the expectation of the user cannot be met.

[0059] In view of this fact, the second embodiment regenerates the DPF 36 when the output torque of the engine 10 is limited by a torque limit value to fall to or below the required torque TCUR, more specifically, when the fuel injection quantity Q is limited to make the output torque of the engine 10 equal to or smaller than the torque limit value TLMT1 so that the limited fuel injection quantity Q becomes equal to or smaller than a fuel injection quantity converted value QCUR converted from the required torque TCUR.

[0060] As shown in FIG. 6, the required torque TCUR is defined or determined as a table value retrievable using the engine speed NE because the output torque of the engine 10 varies with the engine speed NE.

[0061] Next, in S 120 of FIG. 5, the calculated required torque TCUR is converted into the fuel injection quantity converted value QCUR. The program then goes to S122, in which it is determined whether the fuel injection quantity Q limited to make the output torque equal to or smaller than the torque limit value is equal to or smaller than the converted value QCUR.

[0062] When the result in S 122 is YES, the program goes to S124, in which the bit of a flag FDPF is set to 1, and when the result is NO, the program goes to S126, in which the bit of the flag F.DPF is reset to 0. The bit of the flag F.DPF being set to 1 means that regeneration of the DPF 36 is enabled and its being reset to 0 means that regeneration of the DPF 36 is disabled. When the result in S 114 is NO, the remaining steps of the routine are skipped.

[0063] The regeneration of the DPF 36, which is carried out by another routine executed in parallel with the processing of FIG. 5, will be briefly explained. Upon the bit of the flag F.DPF being set to 1, and after the elapse of a prescribed time period, the DPF 36 is regenerated by conducting post-injection.

[0064] The post injection is conducted by injecting a post-injection quantity of fuel at the time of the shift from the power stroke to the exhaust stroke following the combustion that occurs when the ordinary fuel injection explained regarding S18 of the flowchart of FIG. 2 is conducted. The post-injection quantity is determined by calculating a basic value from the engine speed NE and fuel injection quantity Q and suitably correcting the basic value taking other parameters into account.

[0065] Most of the fuel injected by the post-injection does not burn because no compressed air is present. The injected fuel flows through the exhaust system to the oxidation catalytic converter 34 to give rise to an oxidization reaction (combustion). The exhaust gas heated by the combustion flows into the DPF 36 located downstream to burn and remove the accumulated particulates captured by the DPF 36. As a result, the DPF 36 is unclogged and regenerated.

[0066] On the other hand, whether or not the accumulated particulates have been burned and removed is discriminated by, for example, comparing the detected differential pressure PDIF with a predetermined value. When the result of the discrimination is affirmative, it is determined that regeneration of the DPF 36 has been completed and the bit of the flag F.DPF is reset to 0.

[0067] The second embodiment is thus configured, in addition to the configuration of the first embodiment, to further include: required output calculating means (62, S 118, S120) for calculating a required output of the engine (TCUR); and filter regeneration executing means (62, S122, S124) for executing regeneration of the filter when the output of the engine limited to the upper limit value is equal to or smaller than the required output.

[0068] As explained in the foregoing, the second embodiment is configured to regenerate the DPF 36 when the fuel injection quantity Q limited to the upper limit value is equal to or smaller than the fuel injection quantity converted value QCUR converted from the torque TCUR required by the engine 10. As a result, the required torque TCUR, i.e., the torque necessary to make the engine 10 an appealing product from the perspective of the user, can be realized, so that the expectation of the user can be met.

[0069] Further, the engine output control system is configured to regenerate the DPF 36 only when the fuel injection quantity Q limited to the upper limit value is equal to or smaller than the fuel injection quantity converted value QCUR. Regeneration of the DPF 36 can therefore be kept to the necessary minimum because the fuel injection quantity Q is not limited to the upper limit value during low-load operation such as when the vehicle powered by the engine 10 is driven on a congested road. Therefore, when the regeneration of the DPF 36 is carried out by post-injection, the decline in fuel performance can be minimized and oil dilution can be reduced.

[0070] It should be noted in the above that, although it is explained in the foregoing that the output of the engine 10 is restricted by setting the fuel injection quantity Q equal to or lower than the fuel injection quantity limit value QLMT, this is not a limitation and it is possible instead to restrict the output of the engine 10 by lowering the common rail pressure (fuel pressure) or restrict the output of the engine 10 by retarding the injection timing.

[0071] It should also be noted that, although the foregoing embodiments use the first-order delay PPREDPFF of the exhaust gas pressure PPREDPF, they can of course instead use the exhaust gas pressure PPREDPF.

[0072] It should further be noted that, although the foregoing embodiments regenerate the DPF 36 by post-injection, the regeneration can instead be achieved, for example, by retarding the ordinary fuel injection timing or closing the intake shutter 16.

[0073] It should still further be noted that, although the foregoing explanation is made taking application of the invention to a vehicle engine as an example, the invention can also be applied to an engine for a boat propulsion system such as an outboard motor having a vertically oriented crankshaft.

[0074] In an engine output control system, the exhaust gas pressure PPREDPF immediately before the DPF (filter) that captures particulates entrained by the exhaust gas is detected (S100 to S104), the engine output upper limit value (TLMT1) is calculated so that the upper limit value decreases with increasing exhaust gas pressure (S106), and the engine output is controlled based on the calculated upper limit value (S108 to S 116). Thus, by ascertaining rise in the temperature and pressure of the exhaust system owing to clogging of the DPF virtually directly and restricting the output of the engine accordingly, excessive exhaust temperature increase can be avoided, thereby preventing degradation of exhaust system components, and excessive exhaust gas pressure increase can be avoided, thereby inhibiting exhaust gas leakage from exhaust system component joints with high reliability.

Claims

1. A system for controlling an output of an internal combustion engine (10) having a filter (36) installed in an exhaust system (24, 26) for capturing particulates entrained by exhaust gas produced by the engine, **characterized by**:

    exhaust pressure detecting means (62, S100 to S104) for detecting an exhaust gas pressure before the filter (PPREDPF, PPREDPFF);

engine output upper limit value calculating means (62, S106) for calculating an upper limit value (TLMT1) of the output of the engine (10) based on the detected exhaust gas pressure such that the upper limit value (TLMT1) decreases as the exhaust gas pressure increases; and
engine output controlling means (62, S 108 to S 116, S 18) for controlling the output of the engine based on the calculated upper limit value (TLMT1).

2. The system according to claim 1, further including:

engine speed detection means (40, 62) for detecting a speed NE of the engine (10):
and the engine output upper limit value calculating means calculates the upper limit value so as to decrease with increase of the exhaust gas pressure (PPREDPF, PPREDPFF) and engine speed NE (62, S106).

3. The system according to claim 1 or 2, further including:

required output calculating means (62, S118, S120) for calculating a required output of the engine (TCUR); and
filter regeneration executing means (62, S122, S124) for executing regeneration of the filter when the output of the engine limited to the upper limit value is equal to or smaller than the required output.

4. A method of controlling an output of an internal combustion engine (10) having a filter (36) installed in an exhaust system (24, 26) for capturing particulates entrained by an exhaust gas produced by the engine, **characterized by** the steps of:

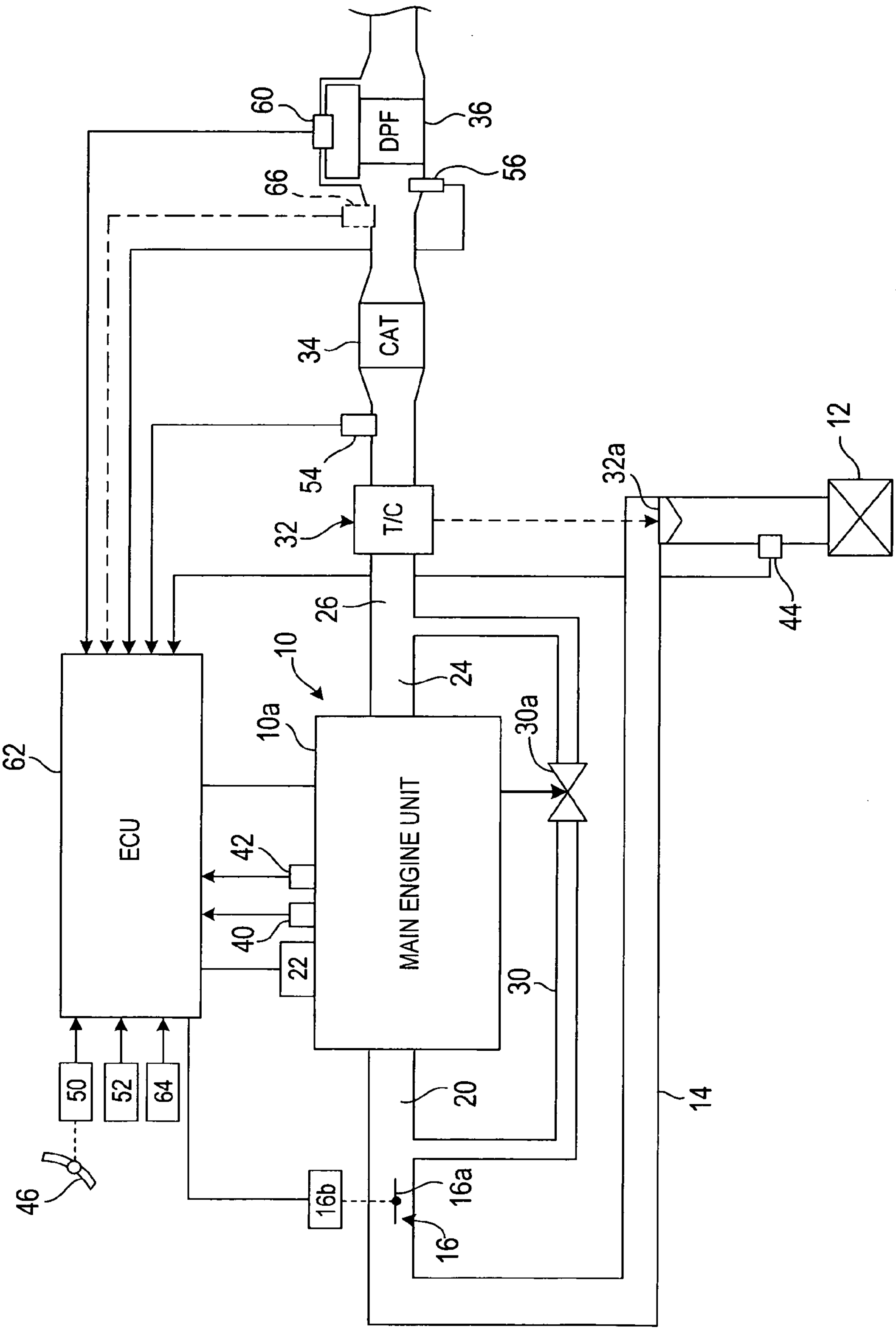
detecting an exhaust gas pressure before the filter (PPREDPF, PPREDPFF) (62, S 100 to S 104);
calculating an upper limit value (TLMT1) of the output of the engine (10) based on the detected exhaust gas pressure such that the upper limit value (TLMT1) decreases as the exhaust gas pressure increases (62, S106); and
controlling the output of the engine based on the calculated upper limit value (TLMT1) (62, S 108 to S116, S18).

5. The method according to claim 4, further including the step of:

detecting a speed NE of the engine (10)
and the engine output upper limit value calculation means calculates the upper limit value so as to decrease with increase of the exhaust gas pressure (PPREDPF, PPREDPFF) and engine speed NE (62, S106).

6. The method according to claim 4 or 5, further including the steps of:

calculating a required output of the engine (TCUR) (62, S 118, S 120); and
executing regeneration of the filter when the output of the engine limited to the upper limit value is equal to or smaller than the required output (62, S122, S124).


DPF
CAT
T/C
ECU
MAIN ENGINE UNIT
10
10a
12
14
16
16a
16b
20
22
24
26
30
30a
32
32a
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42
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64
66

FIG. 1

FIG. 2

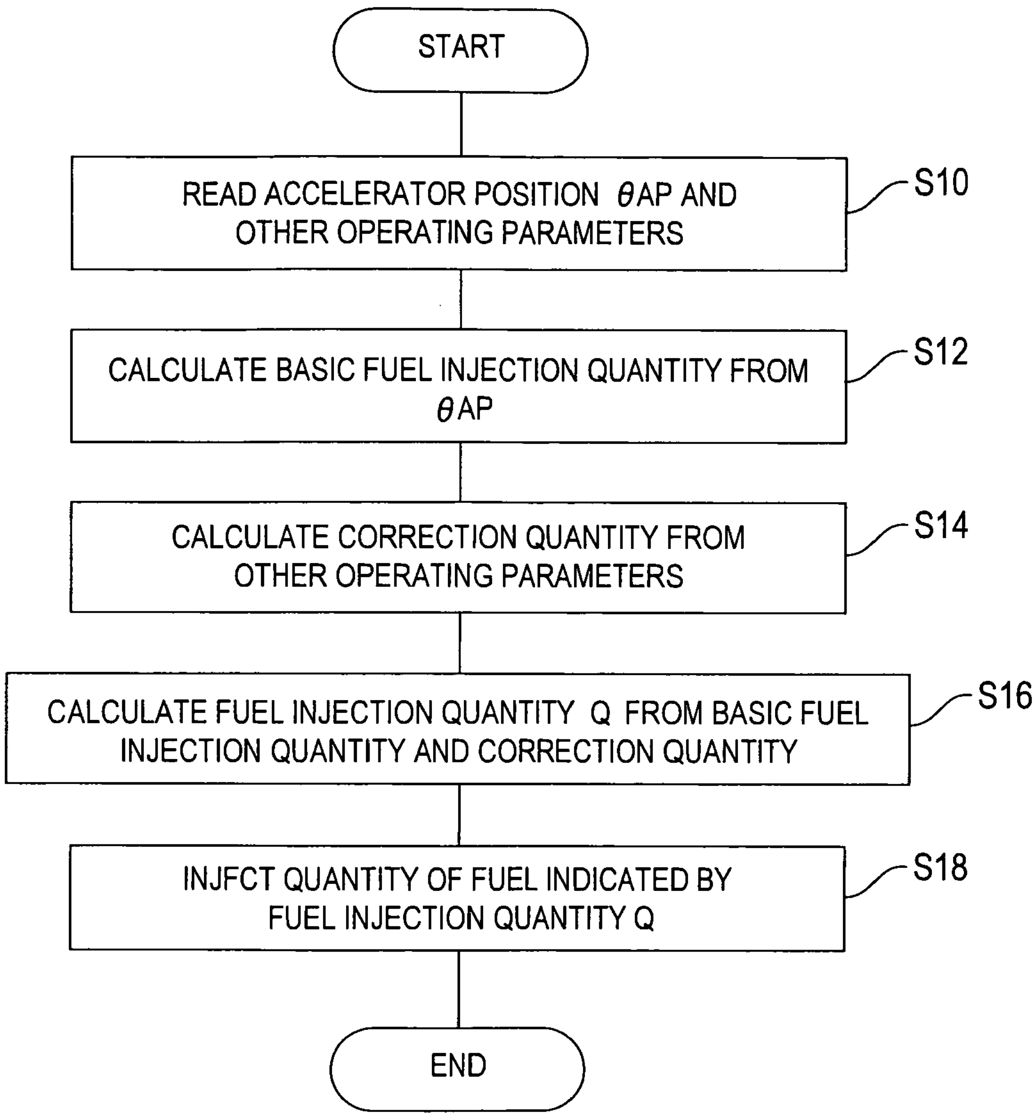

START
READ ACCELERATOR POSITION θAP AND OTHER OPERATING PARAMETERS
S10
CALCULATE BASIC FUEL INJECTION QUANTITY FROM θAP
S12
CALCULATE CORRECTION QUANTITY FROM OTHER OPERATING PARAMETERS
S14
CALCULATE FUEL INJECTION QUANTITY Q FROM BASIC FUEL INJECTION QUANTITY AND CORRECTION QUANTITY
S16
INJFCT QUANTITY OF FUEL INDICATED BY FUEL INJECTION QUANTITY Q
S18
END

FIG. 3

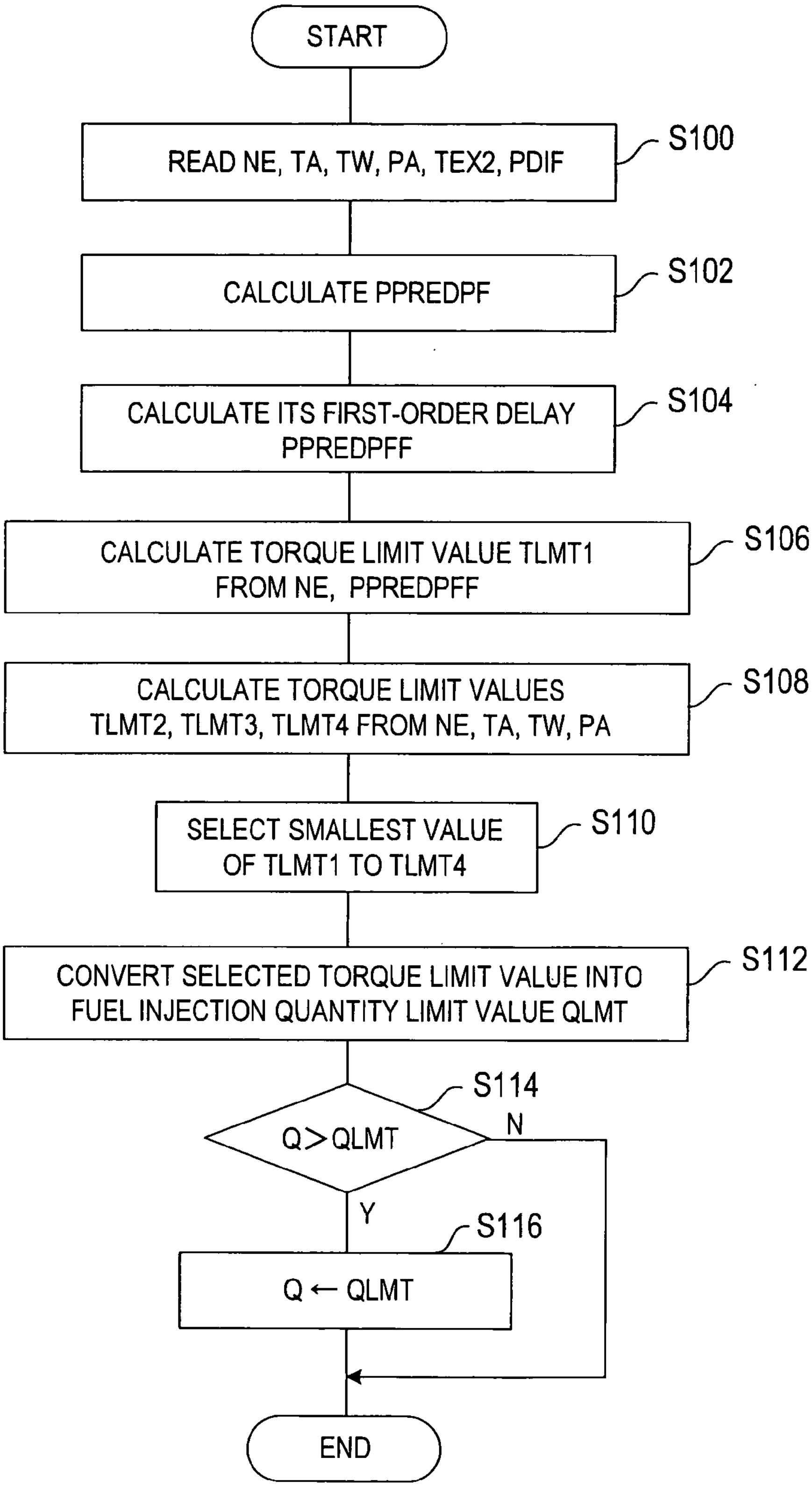

START
READ NE, TA, TW, PA, TEX2, PDIF
S100
CALCULATE PPREDPF
S102
CALCULATE ITS FIRST-ORDER DELAY PPREDPFF
S104
CALCULATE TORQUE LIMIT VALUE TLMT1 FROM NE, PPREDPFF
S106
CALCULATE TORQUE LIMIT VALUES TLMT2, TLMT3, TLMT4 FROM NE, TA, TW, PA
S108
SELECT SMALLEST VALUE OF TLMT1 TO TLMT4
S110
CONVERT SELECTED TORQUE LIMIT VALUE INTO FUEL INJECTION QUANTITY LIMIT VALUE QLMT
S112
Q>QLMT
S114
N
Y
Q ← QLMT
S116
END

FIG. 4

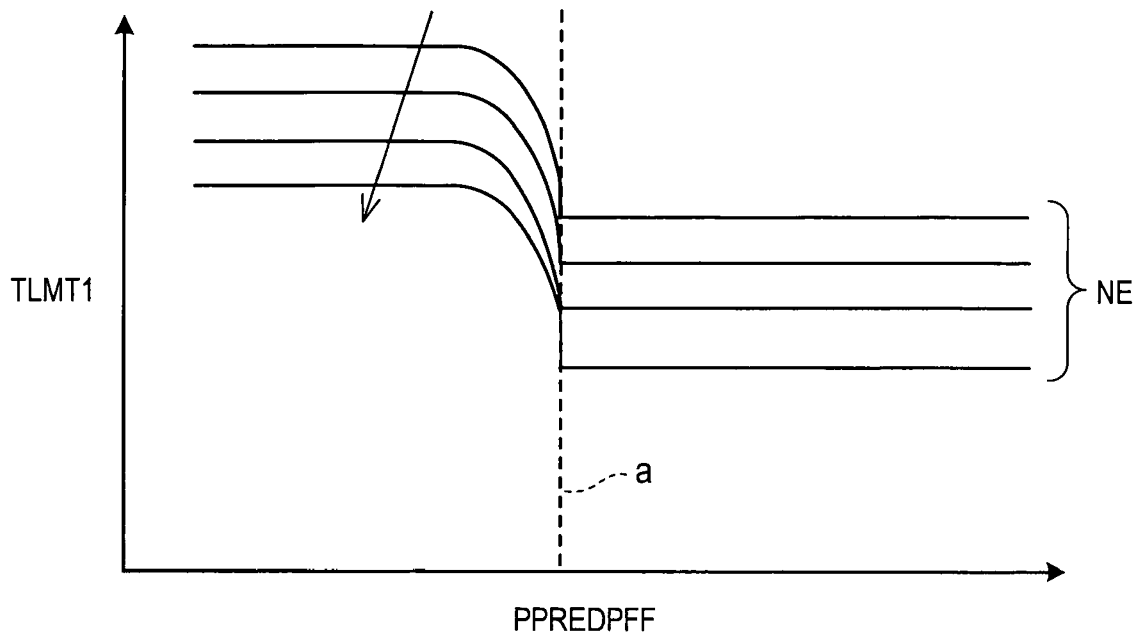


FIG. 5

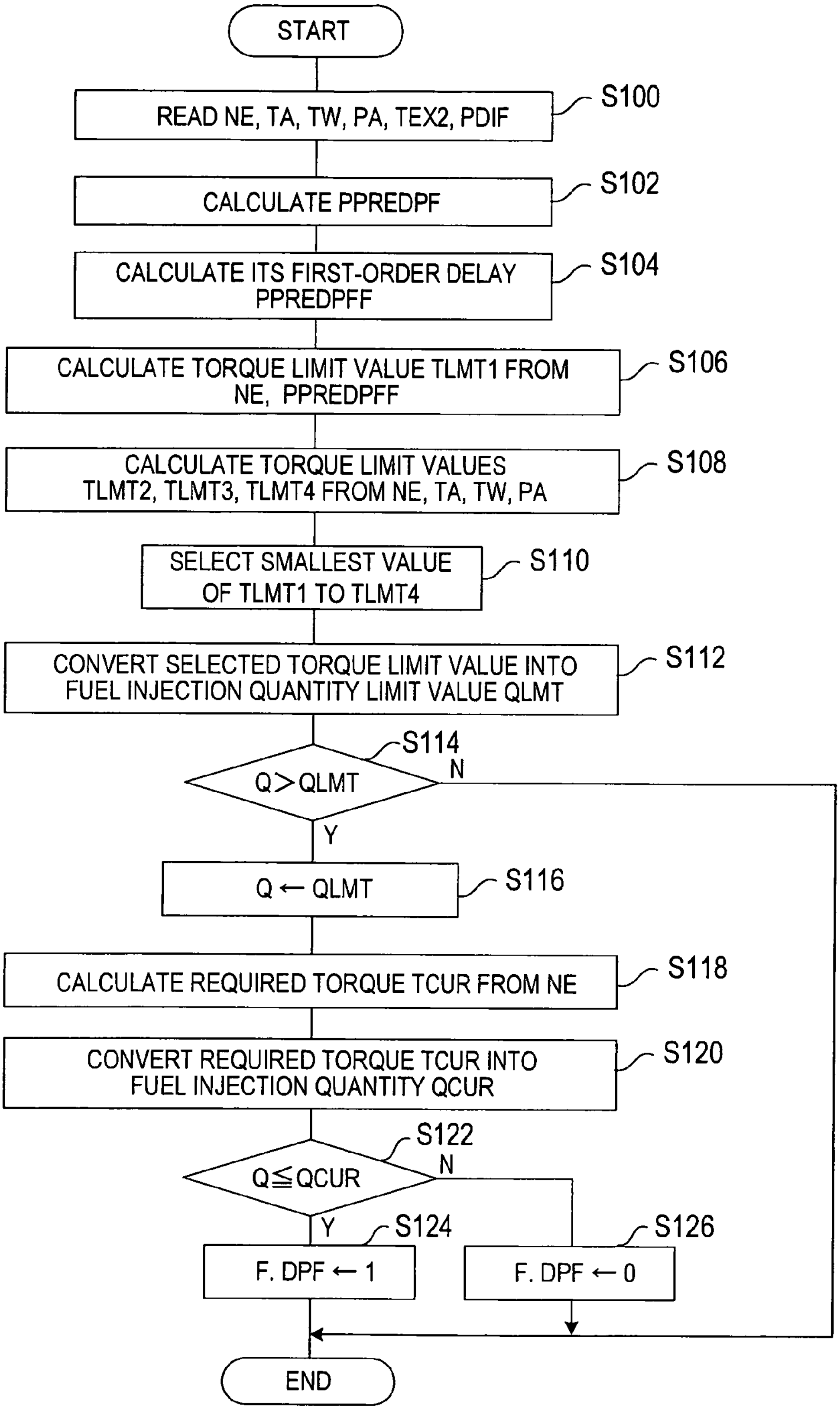
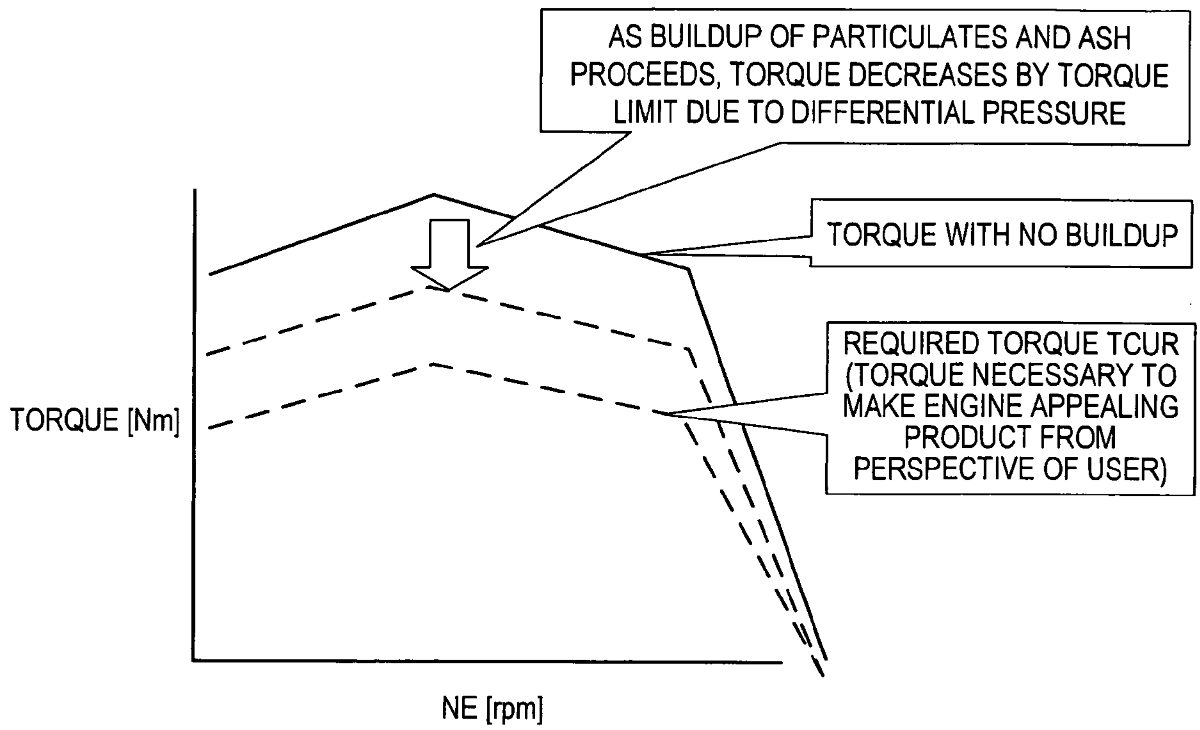

START
READ NE, TA, TW, PA, TEX2, PDIF
S100
CALCULATE PPREDPF
S102
CALCULATE ITS FIRST-ORDER DELAY PPREDPFF
S104
CALCULATE TORQUE LIMIT VALUE TLMT1 FROM NE, PPREDPFF
S106
CALCULATE TORQUE LIMIT VALUES TLMT2, TLMT3, TLMT4 FROM NE, TA, TW, PA
S108
SELECT SMALLEST VALUE OF TLMT1 TO TLMT4
S110
CONVERT SELECTED TORQUE LIMIT VALUE INTO FUEL INJECTION QUANTITY LIMIT VALUE QLMT
S112
S114
Q>QLMT
N
Y
Q ← QLMT
S116
CALCULATE REQUIRED TORQUE TCUR FROM NE
S118
CONVERT REQUIRED TORQUE TCUR INTO FUEL INJECTION QUANTITY QCUR
S120
S122
Q≦QCUR
N
Y
S124
F. DPF ← 1
S126
F. DPF ← 0
END

FIG. 6


AS BUILDUP OF PARTICULATES AND ASH PROCEEDS, TORQUE DECREASES BY TORQUE LIMIT DUE TO DIFFERENTIAL PRESSURE
TORQUE WITH NO BUILDUP
REQUIRED TORQUE TCUR (TORQUE NECESSARY TO MAKE ENGINE APPEALING PRODUCT FROM PERSPECTIVE OF USER)
TORQUE [Nm]
NE [rpm]

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 00 9583

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	FR 2 840 959 A (RENAULT S.A.S) 19 December 2003 (2003-12-19) * page 2, line 27 - page 3, line 10 * * page 5, line 27 - page 7, last line * * figures *	1,4	INV. F02D41/02 F02D41/14
A	US 2004/093854 A1 (OAKES JEFFREY L ET AL) 20 May 2004 (2004-05-20) * paragraph [0026] - paragraph [0028] * * figures 2,3 *	1,4	
D,A	EP 1 400 673 A (ISUZU MOTORS LIMITED) 24 March 2004 (2004-03-24) * paragraph [0014] - paragraph [0017] * * paragraph [0033] - paragraph [0034] * * figure 4 *	1,4	
A	EP 1 318 287 A (RENAULT S.A.S) 11 June 2003 (2003-06-11) * paragraph [0026] * * figure 4 *	1,4	TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 July 2006	De Vita, D

1

CATEGORY OF CITED DOCUMENTS

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The members are as contained in the European Patent Office EDP file on
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21-07-2006

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