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(54) **A method and device for controlling black smoke in a diesel engine**

(57) A method of controlling black smoke in a diesel engine, having a control unit (6) for controlling the injection pressure of the fuel. The method comprises the steps of determining a first parameter which is representative of the instantaneous engine speed, determining a second parameter which is representative of the

instantaneous quantity of oxygen present in the combustion chambers of the engine, determining a third parameter relating to the instantaneous injection pressure of the fuel, and providing a signal (F) which is representative of the actual admissible fuel supply or of the actual admissible air-fuel ratio, on the basis of the first, second and third parameters.

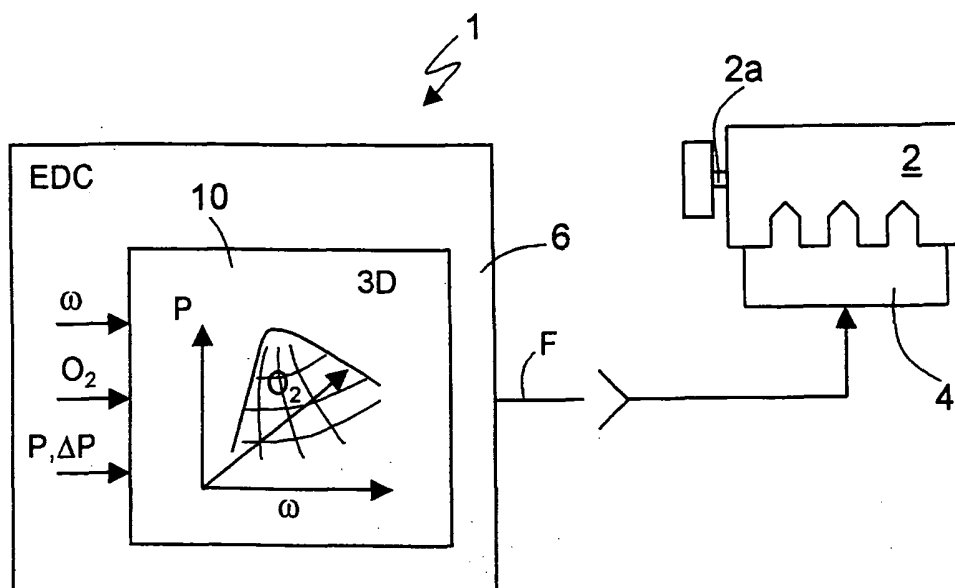


Fig. 1

Description

[0001] The present invention relates to a method and device for controlling black smoke in a diesel engine.

[0002] It is known that diesel engines are provided with a smoke-control system for limiting the emissions of black smoke during transition periods (for example acceleration) of the engine. The control of the emission of black smoke is ideally brought about by controlling the quantity of fuel injected as a function of the quantity of oxygen actually available for combustion. Currently, however, there is no sensor available which is technologically reliable for the direct measurement of the quantity of oxygen available. The technique commonly adopted is to derive a value which is representative of the air flow rate measured, of the supercharging pressure measured or of the total air-fuel ratio (λ).

[0003] The above-mentioned control is suitably brought about by means of a two-dimensional (2D) retrieval array which receives two input parameters, namely:

- a) a parameter relating to the quantity of oxygen actually present in the combustion chamber, i.e. the mass of air actually contained in the combustion chamber; and
- b) a parameter which is representative of the current engine speed.

[0004] Said two-dimensional retrieval array emits a signal which is indicative of the actual admissible fuel supply or of the actual admissible air-fuel ratio as a function of the real magnitude of the two input parameters.

[0005] Independently of their particular characteristics, known smoke-control systems take into consideration only the admissible oxygen-fuel combustion ratio as a function of the present operating condition of the engine.

[0006] However, if the fuel-injection system used provides control of the injection pressure (for example a common rail system), the injection pressure can deviate from its given value during the transient operation of the engine. This means that the injection pressure may exhibit a delay when it is controlled at variable values within the operating range of the engine.

[0007] This delay does in fact influence the emission behaviour of the smoke but this effect is not recognised by known smoke control means.

[0008] Essentially, an excessively low injection pressure increases the emission of smoke.

[0009] The aforementioned drawback is obviated by the present invention which relates to a method and a device for controlling black smoke in a diesel engine in accordance with the attached claims, which are considered an integral part of the present description.

[0010] The invention will be described with reference to the accompanying drawings which illustrate a non-restrictive example of the invention, in which:

- Figure 1 shows schematically an apparatus for controlling black smoke from a diesel engine, devised in accordance with a first embodiment of the invention; and
- Figure 2 shows schematically an apparatus for controlling black smoke from a diesel engine, devised in accordance with a second embodiment of the invention.

[0011] In Figure 1 the reference numeral 1 generally denotes an apparatus for controlling black smoke from a diesel engine 2 (shown schematically).

[0012] The diesel engine 2 is provided with a fuel-injection system 4 of known type, for example a common rail system, which injects fuel under pressure into combustion chambers (not shown) of the diesel engine 2.

[0013] The fuel injection system 4 is controlled by an electronic diesel control unit (EDC) 6 which receives input signals principally measured in the engine and emits control signals for the diesel engine 2.

[0014] The electronic diesel control unit (EDC) 6 controls the quantity of fuel injected and the injection pressure of the fuel in a known manner. The electronic diesel control unit (EDC) 6 also performs a control of the black smoke of the diesel engine 2 so as to limit the emission of black smoke during transition periods (for example under acceleration) of the engine 2.

[0015] For this purpose the EDC 6 is provided with a three-dimensional array 10 (3D) which receives the following input parameters:

- a) a first parameter O_2 relating to the actual quantity of oxygen in the combustion chambers, for example mass of air actually contained in the combustion chambers;
- b) a second parameter ω which is representative of the instantaneous engine speed (obtained for example by measuring the speed of rotation of the crankshaft 2A of the engine 2); and
- c) a third parameter p which is representative of the instantaneous injection pressure of the fuel in the fuel-injection system 4.

[0016] The fuel-injection pressure p can preferably be represented by the pressure present in the duct of a common rail system.

[0017] The third parameter c) can also represent the deviation Δp in the instantaneous injection pressure of the fuel in the fuel-injection system 4 with respect to a reference pressure p_0 , i.e. $\Delta p = p - p_0$.

[0018] Said 3D array 10, for each combination of three input parameters, emits a signal F which is representative of the actual admissible fuel supply or the actual admissible air-fuel ratio which has to be provided by means of the fuel-injection system 4.

[0019] The signal F is thus used to control the fuel-injection system 4 so that the quantity of fuel which is supplied to the engine 2 is correlated to the injection

pressure. Therefore, the irregular emission of smoke caused by variations in pressure is eliminated.

[0020] In the embodiment illustrated in Figure 2, the electronic diesel control unit (EDC) 6 performs a control of the black smoke of the diesel engine 2 so as to limit the emissions of smoke during the transient operating period (for example under acceleration) of the engine 2.

[0021] For this purpose, the EDC 6 is provided with a two-dimensional array 12 (2D) which receives the following input parameters:

- a) a first parameter O_2 relating to the actual quantity of oxygen in the combustion chambers, i.e. the mass of air actually contained in the combustion chambers;
- b) a second parameter ω which is representative of the instantaneous engine speed (obtained for example by measuring the speed of rotation of the crankshaft 2A of the engine 2).

[0022] Said array 12, for each combination of the two input parameters, emits an approximate signal Fr which is representative, initially approximately, of the actual admissible fuel supply or of the actual admissible air-fuel ratio which should be provided by the fuel-injection system 4.

[0023] The approximate signal Fr is fed to a correction block 15 in which the approximate signal Fr is multiplied by a corrective gain factor G so as to emit a corrected signal Fc used to control the fuel-injection system 4 so that the quantity of fuel supplied to the engine 2 is linked to the injection pressure of the fuel.

[0024] The value of the gain factor G is correlated to the deviation Δp in the instantaneous injection pressure of the fuel in the fuel-injection system 4 with respect to a reference pressure p_0 , i.e. $\Delta p = p - p_0$.

[0025] For example, the gain factor G may be emitted by way of an array 17 which emits a value G for each input value Δp .

[0026] In particular, if the instantaneous injection pressure p is lower than the reference pressure p_0 , the gain factor G is less than 1, when the difference Δp is near to 0, the gain factor G is near to 1 and if the injection pressure p is higher than the reference value p_0 , the gain factor is ≥ 1 .

[0027] According to another embodiment, the corrective gain factor G can also be linked to the instantaneous speed of the engine. In this embodiment, the array 17 may comprise a two-dimensional map (2G) with two input parameters which are representative of the engine speed and of the injection pressure of the fuel or, respectively, of the deviation in the injection pressure.

[0028] The present invention can be advantageously implemented through a program for computer, preferably arranged and running in the electronic diesel control unit EDC, comprising program coding means for the implementation of one or more steps of the method, when this program is running on a computer or a microproc-

essor system. Therefore, it is understood that the scope of protection is extended to such a program for computer and in addition to a computer readable means having a recorded message therein, said computer readable means comprising program coding means for the implementation of one or more steps of the method, when this program is run on a computer or a microprocessor system.

[0029] Many changes, modifications, variations and other uses and applications of the subject invention will become apparent to those skilled in the art after considering the specification and the accompanying drawings which disclose preferred embodiments thereof. All such changes, modifications, variations and other uses and applications which do not depart from the spirit and scope of the invention are deemed to be covered by this invention.

20 Claims

1. A method for controlling black smoke in a diesel engine, **characterised by** comprising the following steps:

- determining a first parameter (ω) which is representative of the instantaneous engine speed;
- determining a second parameter (O_2) correlated to the instantaneous quantity of oxygen present in the combustion chambers of the engine;
- determining a third parameter (p ; Δp) correlated to an instantaneous injection pressure of the fuel, and
- providing a signal (F; Fc) which is representative of the actual admissible fuel supply or of the actual admissible air-fuel ratio, on the basis of the first, second and third parameters.

2. A method according to claim 1, **characterized in that** said step of determining said third parameter comprises the step of determining the pressure in the duct (p) of a common rail system.

3. A method according to claim 1, **characterized in that** said step of determining said third parameter comprises the step of determining a parameter which is representative of the difference (Δp) in the instantaneous injection pressure of the fuel (p) with respect to a given value (p_0).

4. A method according to any one of the preceding claims, **characterized in that** said step of providing a signal (F; Fc) which is representative of the actual admissible fuel supply comprises the step of providing said first, second and third parameters to a three-dimensional array (10) which emits, for each combination of the three input signals, said signal

(F;Fc) which is representative of the actual admissible fuel supply or of the actual admissible air-fuel ratio.

5. A method according to any one of the preceding claims, **characterized in that** said step of providing a signal (F;Fc) which is representative of the actual admissible fuel supply comprises the step of providing said first and second parameters to a two-dimensional array (12) which emits, for each combination of the two input signals, an approximate signal (Fr) which is representative of the actual admissible fuel supply or of the actual admissible air-fuel ratio; said method further comprising the step of correcting said approximate signal (Fr). 5 10 15
6. A method according to claim 5, **characterized in that** said correction step comprises the step of multiplying said approximate signals (Fr) by a gain factor (G) which is dependent at least on said third parameter (p; Δp). 20
7. A method according to claim 6, **characterized in that** said gain factor (G) is determined on the basis of said third (p; Δp) and of the instantaneous engine speed (ω). 25
8. A device for controlling black smoke in a diesel engine, **characterised by** comprising means for the implementation of the method of any of claims from 1 to 7. 30
9. Computer program comprising computer program code means adapted to perform all the steps of claims 1 to 7 when said program is run on a computer or a microprocessor system, preferably arranged and running in the device of claim 8. 35 40
10. A computer readable medium having a program recorded thereon, said computer readable medium comprising computer program code means adapted to perform all the steps of claims 1 to 7, when said program is run on a computer or a microprocessor system, preferably arranged and running in the device of claim 8. 45

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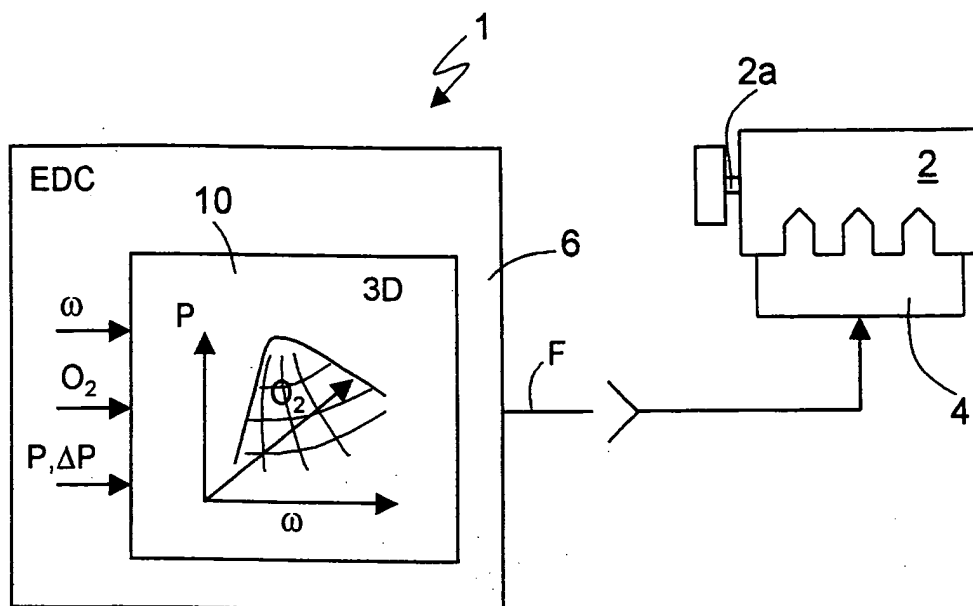


Fig.1

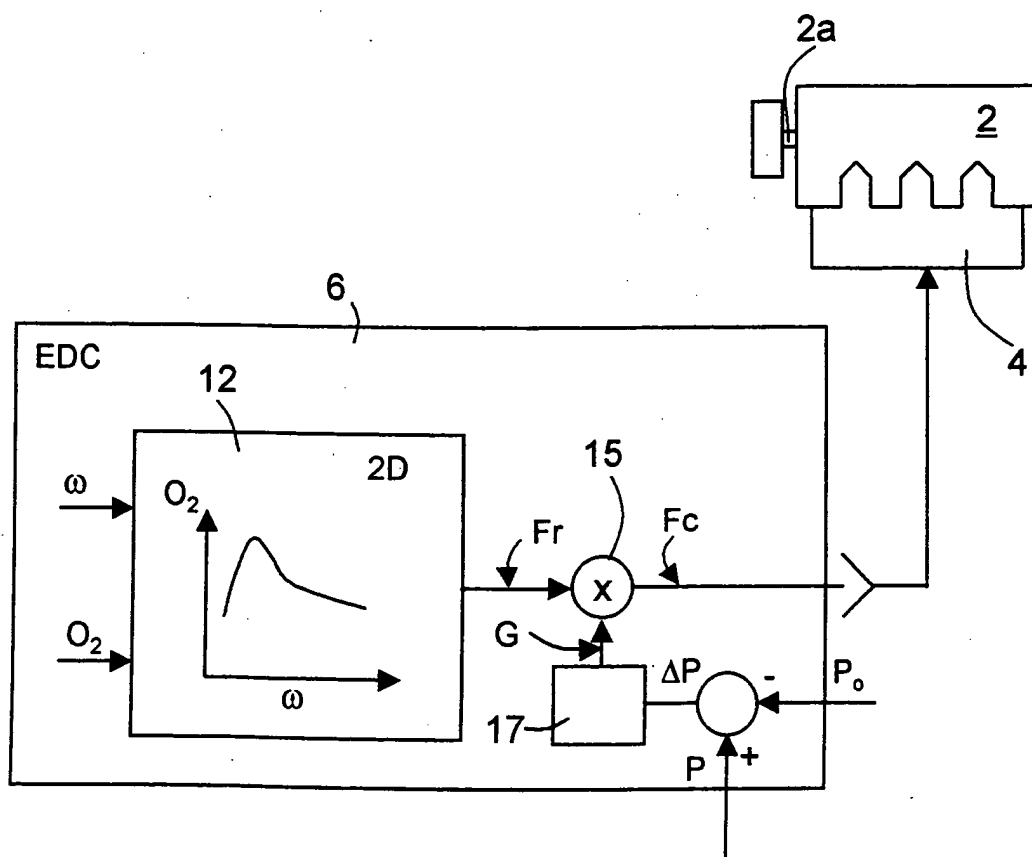


Fig.2



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 03 02 4199

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	EP 1 164 274 A (NISSAN MOTOR) 19 December 2001 (2001-12-19) * abstract * * paragraph '0003! * * paragraphs '0024!-'0026! * * paragraphs '0043!-'0051!; figure 10 * ---	1-10	F02D41/38
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 12 November 2003	Examiner Nicolás, C
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 03 02 4199

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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