(72) Inventors:
• **De Cesare, Matteo**
71017 Torremaggiore (IT)

• **Serra, Gabriele**
40068 S. Lazzaro di Savena (IT)

(74) Representative: **Bergadano, Mirko et al**
Studio Torta S.r.l.
Via Viotti, 9
10121 Torino (IT)

(54) **Method for controlling the temperature of the exhaust gas in an internal combustion engine**

(57) Method of controlling the temperature (T_{exhgas}) of the exhaust gas in an internal combustion engine (1); said method of control consisting of: determining the air/fuel ratio (λ) of the exhaust gas; determining the speed (ω_{mot}) of rotation of the internal combustion engine (1); and estimating the effective temperature (T_{exhgas}) of the exhaust gas as a function of the air/fuel ratio (λ) of the exhaust gas and as a function of the speed (ω_{mot}) of rotation of the internal combustion engine (1).

Fig. 3

EP 2 110 535 A1
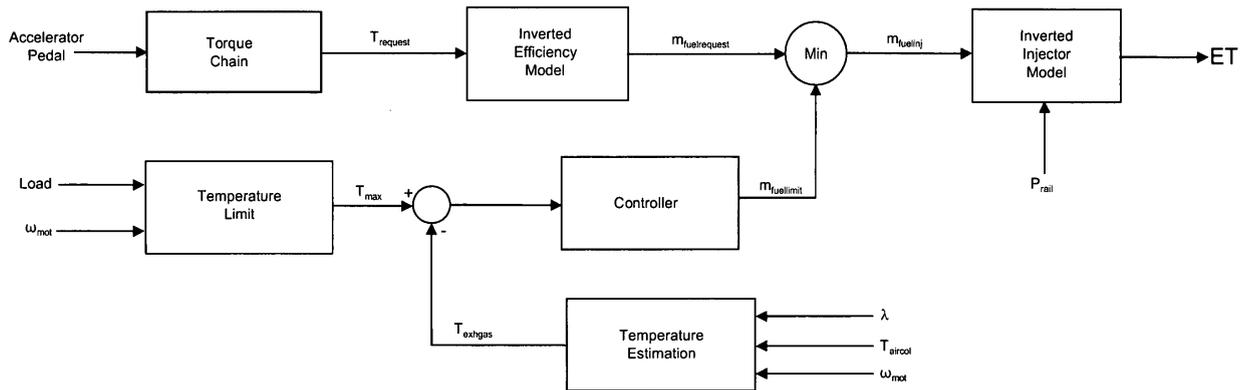
Description

TECHNICAL FIELD

5 **[0001]**   The present invention relates to a method for controlling the temperature of the exhaust gas in an internal combustion engine.

BACKGROUND ART

10 **[0002]**   In an internal combustion engine, the exhaust gas produced during combustion in the cylinders reaches high temperatures which in turn cause significant heating of all the components through which said exhaust gas flows, namely the cylinder head, the exhaust manifold, the exhaust system (ducts, catalysts and mufflers) and, if present, the turbine of the turbocharger. The parts that become the hottest are clearly those which are closest to the cylinders and which are not cooled by the fluid cooling system, namely the exhaust manifold and, if present, the turbocharger turbine.

15 **[0003]**   One purpose of the engine control system is to control the maximum temperature of the exhaust gas in order to limit the maximum temperature reached by the components through which the exhaust gas flows, particularly with the engine at full power or almost at full power, i.e. with a high exhaust gas flow rate (and thus with a high heating capacity). However, the inevitable structural leakages and variations that occur over time which affect all the components of an internal combustion engine can lead to errors, which may even be significant, in the strategy adopted to limit the

20 maximum temperature of the exhaust gas and thus despite the intervention of the strategy to limit the maximum temperature of the exhaust gas the effective temperature of the exhaust gas may exceed the maximum limit defined in the design stage so that the components through which the exhaust gas flows may be exposed to excessive heating which can cause mechanical stress and eventually lead to deformations, cracking and even breakage due to fatigue.

[0004]   For example, over-performance by the fuel injectors (i.e. if the fuel injectors supply more than the set amount

25 of fuel) may cause a sudden rise in the maximum temperature of the exhaust gas; similarly, under-performance by the pressure sensor in the intake manifold (i.e. if the pressure in the intake manifold is underestimated) may cause a sudden rise in the maximum temperature of the exhaust gas as this value is used as a feedback variable for controlling the turbocharger.

[0005]   Installing a temperature sensor in the exhaust manifold of the internal combustion engine in order to obtain a

30 direct measurement of the temperature of the exhaust gas has been proposed as a solution for preventing excessive heating of the components through which the exhaust gas flows. This solution is certainly effective, in that when the temperature of the exhaust gas is read in the exhaust manifold, action can be taken quickly and effectively to limit the maximum temperature of the exhaust gas; however, this solution has the disadvantage of requiring the installation of an additional component (the temperature sensor) which is rather expensive and above all must be installed in an area

35 of the internal combustion engine that is particularly inconvenient due to the high level of thermal stress present in that area.

DISCLOSURE OF INVENTION

[0006]   The purpose of the present invention is to provide a method for controlling the temperature of the exhaust gas

40 in an internal combustion engine, said method of control overcoming the drawbacks described above and, in particular, being easy and inexpensive to produce.

[0007]   According to the present invention a method for controlling the temperature of the exhaust gas in an internal combustion engine is provided according to that set forth in the appended claims.

45 BRIEF DESCRIPTION OF THE DRAWINGS

[0008]   The present invention will now be described with reference to the attached drawings, illustrating a nonlimiting embodiment thereof, in which:

50 -   figure 1 is a schematic illustration of a turbocharged internal combustion engine provided with an electronic control unit which implements a method for controlling the maximum temperature of the exhaust gas according to the present invention;
-    figure 2 is a graph illustrating the result of a test which shows the relationship between the effective temperature of the exhaust gas and the air/fuel ratio of the exhaust gas; and
55 -   figure 3 shows a block diagram of an engine control logic implemented in an electronic control unit of the internal combustion engine of figure 1.

PREFERRED EMBODIMENTS OF THE INVENTION

[0009] In figure 1, number 1 indicates, as a whole, a turbocharged internal combustion engine provided with a turbo-charging system.

[0010] The internal combustion engine 1 comprises four injectors 2 which supply the fuel directly to four cylinders 3, each of which is connected to an intake manifold 4 by means of at least one respective intake valve (not illustrated) and to an exhaust manifold 5 via at least one respective exhaust valve (not illustrated). The intake manifold 4 receives fresh air (i.e. air from the external environment) through an intake duct 6, which is provided with an air filter 7 and is controlled by a butterfly valve 8. An intercooler 9 is arranged along the intake duct 6 for the purpose of cooling the intake air. An exhaust duct 10 is connected to the exhaust manifold 5 and delivers the exhaust gas produced during combustion to an exhaust system, which discharges the combustion gases into the atmosphere and normally comprises at least one catalyst 11 (which may be provided with a particulate filter) and at least one muffler (not illustrated) arranged downstream of the catalyst 11.

[0011] The turbocharging system 2 of the internal combustion engine 1 comprises a turbocharger 12 provided with a turbine 13, which is arranged along the exhaust duct 10 so as to turn at high speed under the action of the exhaust gas discharged by the cylinders 3, and a compressor 14, which is arranged along the intake duct 6 and is mechanically connected to the turbine 13 so as to be made to turn by said turbine 13 to increase the pressure of the air in the intake duct 6.

[0012] A bypass duct 15 is provided along the exhaust duct 10 and is connected in parallel to the turbine 13 so that the ends thereof are connected upstream and downstream of said turbine 13; a wastegate valve 16 is arranged along the bypass duct 15 and is suited to regulate the flow rate of the exhaust gas through the bypass duct 15 and is controlled by a solenoid valve 17. A bypass duct 18 is provided along the intake duct 6 and is connected in parallel to the compressor 14 so that the ends thereof are connected upstream and downstream of said compressor 14; a pop-off valve 19 is arranged along the bypass duct 18 and is suited to regulate the flow rate of the exhaust gas through the bypass duct 18 and is controlled by a solenoid valve 20.

[0013] The internal combustion engine 1 is controlled by an electronic control unit 21, which manages the operation of all the components of the internal combustion engine 1. The electronic control unit 21 is connected to a sensor 22 which measures the temperature T_{aircol} and the pressure P_{aircol} of the air in the intake manifold 4, to a sensor 23 which measures the speed ω_{mot} of rotation of the internal combustion engine, and to a sensor 24 (typically an oxygen linear sensor of the UEGO type) which measures the air/fuel ratio of the exhaust gas upstream of the catalyst 11.

[0014] One function of the electronic control unit 21 is to implement a control strategy to limit the effective temperature T_{exhgas} of the exhaust gas in order to prevent excessive heating of all the components through which said exhaust gas flows. The method of control used by the electronic control unit 21 to limit the effective temperature T_{exhgas} of the exhaust gas will now be described.

[0015] The electronic control unit 21 estimates the effective temperature T_{exhgas} of the exhaust gas essentially as a function of the air/fuel ratio λ of the exhaust gas. In particular, the electronic control unit 21 estimates an increase ΔT in temperature essentially as a function of the air/fuel ratio λ of the exhaust gas and then calculates the effective temperature T_{exhgas} of the exhaust gas by adding the increase ΔT in temperature to the temperature T_{aircol} of the air in the intake manifold 4 according to the following equation:

$$[1] \quad T_{exhgas} = T_{aircol} + \Delta T(\lambda, \omega_{mot})$$

T_{exhgas} effective temperature of the exhaust gas;
T_{aircol} temperature of the air in the intake manifold 4;
ΔT increase in temperature;
λ air/fuel ratio of the exhaust gas;
ω_{mot} speed of rotation of the internal combustion engine 1.

[0016] According to a preferred embodiment, the increase ΔT in temperature is calculated as a function of the air/fuel ratio λ of the exhaust gas and as a function of the speed ω_{mot} of rotation of the internal combustion engine 1; it is important to note that in calculating the increase ΔT in temperature the main variable is the air/fuel ratio λ of the exhaust gas while the speed ω_{mot} of rotation of the internal combustion engine 1 is merely a correction variable.

[0017] It is also important to note that the electronic control unit 21 only estimates the effective temperature T_{exhgas} of the exhaust gas as a function of the air/fuel ratio λ of the exhaust gas as described above when the speed ω_{mot} of rotation of the internal combustion engine 1 exceeds a threshold value determined in the design stage; the relationship between the effective temperature T_{exhgas} of the exhaust gas and the air/fuel ratio λ of the exhaust gas is in actual fact

only reliable at high or medium-high engine speeds. It is important to note that, in practice, said limitation in the estimation of the effective temperature T_{exhgas} of the exhaust gas is irrelevant, in that at low or medium speeds combustion only involves a limited amount of fuel and air and the flow rate and temperature of the exhaust gas are therefore also limited; consequently, no practical advantage is gained from controlling and limiting the effective temperature T_{exhgas} of the exhaust gas at low or medium speeds since at low or medium speeds the components through which the exhaust gas flows are never subjected to excessive heating.

[0018] In particular, it has been observed that at high or medium-high speeds, the variation in the effective temperature T_{exhgas} of the exhaust gas is inversely proportional to the air/fuel ratio λ of the exhaust gas so that when the air/fuel ratio λ of the exhaust gas increases the effective temperature T_{exhgas} of the exhaust gas falls and vice versa.

[0019] According to a preferred embodiment, the law whereby the effective temperature T_{exhgas} of the exhaust gas is a function of the air/fuel ratio λ of the exhaust gas and a function of the speed ω_{mot} of rotation of the internal combustion engine 1 is determined on the basis of tests performed in the design stage and during set-up of the internal combustion engine 1 and is stored by points in a memory of the electronic control unit 21. In other words, during the design and set-up of the internal combustion engine 1 the internal combustion engine 1 is provided with a temperature sensor that directly and extremely precisely measures the effective temperature T_{exhgas} of the exhaust gas; it is thus possible to associate the various air/fuel ratio λ and speed ω_{mot} of rotation combinations with the corresponding effective temperature T_{exhgas} of the exhaust gas.

[0020] By way of example, figure 2 illustrates the result of a test on an internal combustion engine at full load: the continuous line represents the pattern in the air/fuel ratio λ (on the abscissa axis with right scale) as the speed of rotation (on the ordinate axis) changes, while the dashed line represents the trend in the effective temperature T_{exhgas} of the exhaust gas (on the abscissa axis with left scale) when the speed of rotation (on the ordinate axis) changes. It is clear that at high speeds of rotation, the variation in the effective temperature T_{exhgas} of the exhaust gas is inversely proportional to the air/fuel ratio λ of the exhaust gas.

[0021] The above description with respect to the relationship between the effective temperature T_{exhgas} of the exhaust gas and the air/fuel ratio λ of the exhaust gas can be justified by referring to the simplified energy balance equation applied to the internal combustion engine 1, considering in particular the points where no EGR is present (high speeds of rotation and high loads) :

$$[2] \quad m_{fuel} \cdot H_{cal} = T \cdot \omega_{mot} + cp \cdot m_{air} \cdot (T_{exhgas} - T_{aircol}) + h \cdot$$

$$S_{cyl} \cdot (T_{gascyl} - T_{cooling})$$

m_{fuel}	amount of fuel injected into the cylinders;
H_{cal}	lowest calorific value of the fuel;
T	engine torque generated;
ω_{mot}	speed of rotation of the internal combustion engine 1;
cp	specific heat of the air;
m_{air}	mass of air drawn into the cylinders 3;
T_{exhgas}	effective temperature of the exhaust gas;
T_{aircol}	temperature of the air in the intake manifold 4;
h	heat transfer coefficient of the cylinders 3;
S_{cyl}	total heat transfer surface of the cylinders 3;
T_{gascyl}	effective temperature of the gas in the cylinders 3;
$T_{cooling}$	temperature of fluid cooling the cylinders 3.

[0022] Once the combustion parameters have been defined (speed of rotation, injection pattern, fuel supply pressure...) the energy introduced via the fuel is spread between the mechanical work generated (engine torque T generated), the heat transferred to the exhaust gas and the heat transferred to the cooling system of the cylinders 3 (water and oil).

[0023] The equation [2] can be used to express the effective temperature T_{exhgas} of the exhaust gas as inversely proportional to the air/fuel ratio λ of the exhaust gas using a coefficient k, which can be determined experimentally and is a function of the speed ω_{mot} of rotation:

$$[3] \quad T_{exhgas} = T_{aircol} + k(\omega_{mot}) \cdot (m_{fuel} / m_{air})$$

$$[4] \quad T_{exhgas} = T_{aircol} + k(\omega_{mot}) / \lambda$$

T_{exhgas}	effective temperature of the exhaust gas;
T_{aircol}	temperature of the air in the intake manifold 4;
k	coefficient that can be determined experimentally as a function of the speed ω_{mot} of rotation;
ω_{mot}	speed of rotation of the internal combustion engine 1;
m_{fuel}	amount of fuel injected into the cylinders;
m_{air}	mass of air drawn into the cylinders 3;
λ	air/fuel ratio of the exhaust gas;

[0024] It is important to note that the equation [4] is exactly equivalent to the equation [1] shown above.

[0025] Figure 3 is a block diagram illustrating an engine control logic implemented in the electronic control unit 21. According to the block diagram illustrated in figure 3, the electronic control unit 21 determines a request $T_{request}$ for torque as a function of the position of an accelerator pedal; based on the request $T_{request}$ for torque the electronic control unit 21 determines a request $m_{fuelrequest}$ for fuel that is limited according to a fuel limit $m_{fuellimit}$. The amount $m_{fuelinj}$ of fuel to be injected consists of the lower between the request $m_{fuelrequest}$ for fuel and the fuel limit $m_{fuellimit}$ so that the amount $m_{fuelinj}$ of fuel to be injected can never exceed the fuel limit $m_{fuemimit}$; the amount $m_{fuelinj}$ of fuel to be injected is used by the electronic control unit 21 to determine (essentially as a function of a fuel delivery pressure P_{rail}) a signal ET to control the fuel injectors 2.

[0026] As a function of the load of the internal combustion engine 1 and as a function of the speed ω_{mot} of rotation of the internal combustion engine 1, the electronic control unit 21 determines the maximum acceptable temperature T_{max} of the exhaust gas that must not be exceeded to avoid damage to the components through which the exhaust gas flows. Moreover, the electronic control unit 21 estimates the effective temperature T_{exhgas} of the exhaust gas as a function of the air/fuel ratio λ of the exhaust gas and as a function of the speed ω_{mot} of rotation of the internal combustion engine 1 as described above. Thus, the electronic control unit 21 compares the maximum acceptable temperature T_{max} of the exhaust gas with the effective temperature T_{exhgas} of the exhaust gas and defines the fuel limit $m_{fuellimit}$ on the basis of the result of said comparison. In other words, the electronic control unit 21 uses the fuel limit $m_{fuellimit}$ to limit, if necessary, the torque generated by the internal combustion engine 1 in order to maintain the effective temperature T_{exhgas} of the exhaust gas at no more than the maximum acceptable temperature T_{max} of the exhaust gas.

[0027] The method for controlling the temperature of the exhaust gas as described above has numerous advantages. In particular, the method for controlling the temperature of the exhaust gas described above is particularly accurate and reliable in that it allows the effective temperature T_{exhgas} of the exhaust gas to be estimated when necessary and to an adequate degree of precision and thus allows the engine control system implemented in the electronic control unit 21 to intervene rapidly and effectively to maintain the maximum temperature of the exhaust gas within the limit set in the design stage. It is important to note that with the method for controlling the temperature of the exhaust gas described above the effective temperature T_{exhgas} of the exhaust gas can be calculated extremely precisely when the internal combustion engine 1 is at full power or almost at full power i.e. when there is most need to effectively limit the maximum temperature of the exhaust gas.

[0028] Moreover, the method for controlling the temperature of the exhaust gas described above is particularly simple and economical to implement in the electronic control unit 21, in that it uses components that are already present in a modern internal combustion engine 1 and therefore does not involve the installation of any specific components.

Claims

1. Method for controlling the temperature (T_{exhgas}) of the exhaust gas in an internal combustion engine (1); the method of control comprising the step of determining the air/fuel ratio (λ) of the exhaust gas; the method of control being **characterized in that** it comprises the additional step of estimating the effective temperature (T_{exhgas}) of the exhaust gas as a function of the air/fuel ratio (λ) of the exhaust gas.

2.   Method of control according to claim 1, wherein to estimate the effective temperature (T_{exhgas}) of the exhaust gas the air/fuel ratio (λ) of the exhaust gas is measured upstream of a catalyst (11).

3.   Method of control according to claim 1 or 2 wherein the variation in the effective temperature (T_{exhgas}) of the exhaust gas is inversely proportional to the air/fuel ratio (λ) of the exhaust gas so that when the air/fuel ratio (λ) of the exhaust gas increases the effective temperature (T_{exhgas}) of the exhaust gas falls.

4.   Method of control according to claim 1, 2 or 3 and comprising the additional steps of:

      determining the temperature of the air in an intake manifold (4); and
      estimating the effective temperature (T_{exhgas}) of the exhaust gas as a function of the air/fuel ratio (λ) of the exhaust gas and as a function of the temperature (T_{aircol}) of the air in the intake manifold (4).

5.   Method of control according to claim 4 and comprising the additional steps of:

      estimating an increase (ΔT) in the temperature as a function of the air/fuel ratio (λ) of the exhaust gas; and
      calculating the effective temperature (T_{exhgas}) of the exhaust gas by adding the increase (ΔT) in temperature to the temperature (T_{aircol}) of the air in the intake manifold (4).

6.   Method of control according to one of the claims from 1 to 5 and comprising the additional steps of:

      determining the speed (ω_{mot}) of rotation of the internal combustion engine (1); and
      estimating the effective temperature (T_{exhgas}) of the exhaust gas as a function of the air/fuel ratio (λ) of the exhaust gas and as a function of the speed (ω_{mot}) of rotation of the internal combustion engine (1).

7.   Method of control according to one of the claims from 1 to 6 and comprising the additional steps of:

      determining the speed (ω_{mot}) of rotation of the internal combustion engine (1); and
      estimating the effective temperature (T_{exhgas}) of the exhaust gas as a function of the air/fuel ratio (λ) of the exhaust gas only if the speed (ω_{mot}) of rotation of the internal combustion engine (1) exceeds a threshold value.

8.   Method of control according to one of the claims from 1 to 7 and comprising the additional steps of:

      determining a maximum acceptable temperature (T_{max}) of the exhaust gas;
      comparing the effective temperature (T_{exhgas}) of the exhaust gas with the maximum acceptable temperature (T_{max}) of the exhaust gas; and
      limiting, if necessary, the torque generated by the internal combustion engine (1) to maintain the effective temperature (T_{exhgas}) of the exhaust gas below the maximum acceptable temperature (T_{max}) of the exhaust gas.

9.   Method of control according to claim 8 and comprising the additional steps of:

      determining the speed (ω_{mot}) of rotation of the internal combustion engine (1);
      determining a load of the internal combustion engine (1); and
      determining the maximum acceptable temperature (T_{max}) of the exhaust gas as a function of the speed (ω_{mot}) of rotation of the internal combustion engine (1) and of the load of the internal combustion engine (1).

10. Method of control according to claim 8 or 9 and comprising the additional step of limiting the torque generated by the internal combustion engine (1) by reducing the amount ($m_{fuelinj}$) of fuel to be injected.

11. Method of control according to claim 10 and comprising the additional steps of:

      determining a fuel limit ($m_{fuellimit}$) as a function of the difference between the effective temperature (T_{exhgas}) of the exhaust gas and the maximum acceptable temperature (T_{max}) of the exhaust gas; and
      limiting the amount ($m_{fuelinj}$) of fuel to be injected according to the fuel limit (mfuellimit).

Amended claims in accordance with Rule 137(2) EPC.

1. Method for controlling the temperature (T_{exhgas}) of the exhaust gas in an internal combustion engine (1); the method of control comprising the steps of:

determining the temperature (T_{aircol}) of the air in an intake manifold (4);
determining the air/fuel ratio (λ) of the exhaust gas; and
estimating the effective temperature (T_{exhgas}) of the exhaust gas as a function of the air/fuel ratio (λ) of the exhaust gas and as a function of the temperature (T_{aircol}) of the air in the intake manifold (4) ;
the method of control being **characterized in that** it comprises the additional step of
determining the speed (ω_{mot}) of rotation of the internal combustion engine (1);
estimating the effective temperature (T_{exhgas}) of the exhaust gas as a function of the air/fuel ratio (λ) of the exhaust gas only and as a function of the temperature (T_{aircol}) of the air in the intake manifold (4) if the speed (ω_{mot}) of rotation of the internal combustion engine (1) exceeds a threshold value;
estimating an increase (ΔT) in the temperature as a function of the air/fuel ratio (λ) of the exhaust gas and as a function of the speed (ω_{mot}) of rotation of the internal combustion engine (1); and
estimating the effective temperature (T_{exhgas}) of the exhaust gas by adding the increase (ΔT) in temperature to the temperature (T_{aircol}) of the air in the intake manifold (4) according to the following equation:

$$T_{exhgas} = T_{aircol} + \Delta T(\lambda, \omega_{mot})$$

T_{exhgas} effective temperature of the exhaust gas;
T_{aircol} temperature of the air in the intake manifold (4);
ΔT increase in temperature;
λ air/fuel ratio of the exhaust gas;
ω_{mot} speed of rotation of the internal combustion engine (1).

2. Method of control according to claim 1, wherein to estimate the effective temperature (T_{exhgas}) of the exhaust gas the air/fuel ratio (λ) of the exhaust gas is measured upstream of a catalyst (11).

3. Method of control according to claim 1 or 2 and comprising the additional steps of:

determining a maximum acceptable temperature (T_{max}) of the exhaust gas;
comparing the effective temperature (T_{exhgas}) of the exhaust gas with the maximum acceptable temperature (T_{max}) of the exhaust gas; and
limiting, if necessary, the torque generated by the internal combustion engine (1) to maintain the effective temperature (T_{axngas}) of the exhaust gas below the maximum acceptable temperature (T_{max}) of the exhaust gas.

4. Method of control according to claim 3 and comprising the additional steps of:

determining the speed (ω_{mot}) of rotation of the internal combustion engine (1);
determining a load of the internal combustion engine (1); and
determining the maximum acceptable temperature (T_{max}) of the exhaust gas as a function of the speed (ω_{mot}) of rotation of the internal combustion engine (1) and of the load of the internal combustion engine (1).

5. Method of control according to claim 3 or 4 and comprising the additional step of limiting the torque generated by the internal combustion engine (1) by reducing the amount ($m_{fuelinj}$) of fuel to be injected.

6. Method of control according to claim 5 and comprising the additional steps of:

determining a fuel limit ($m_{fuellimit}$) as a function of the difference between the effective temperature (T_{exhgas}) of the exhaust gas and the maximum acceptable temperature (T_{max}) of the exhaust gas; and
limiting the amount ($m_{fuelinj}$) of fuel to be injected according to the fuel limit ($m_{fuellimit}$).

Fig. 1

Fig. 2

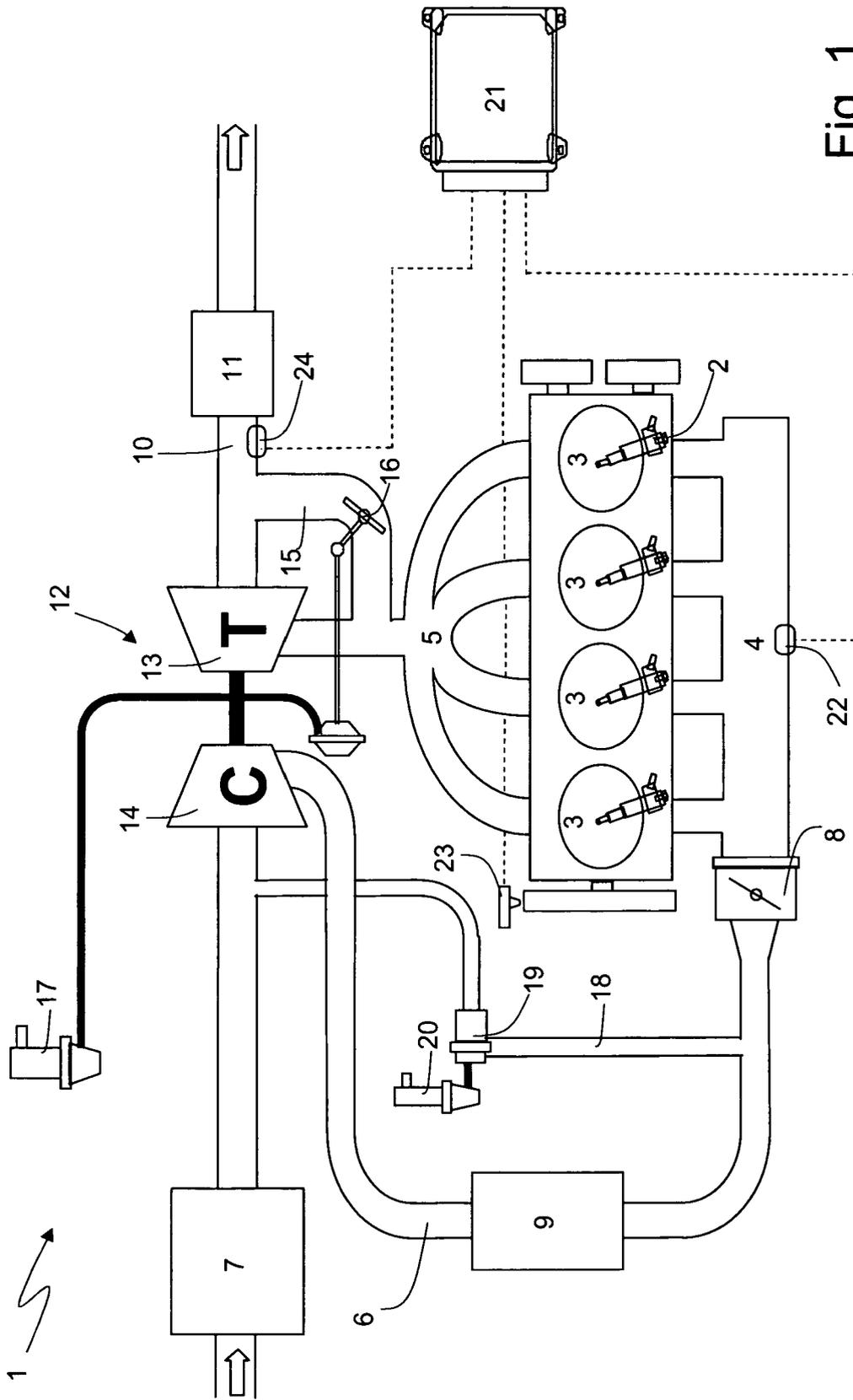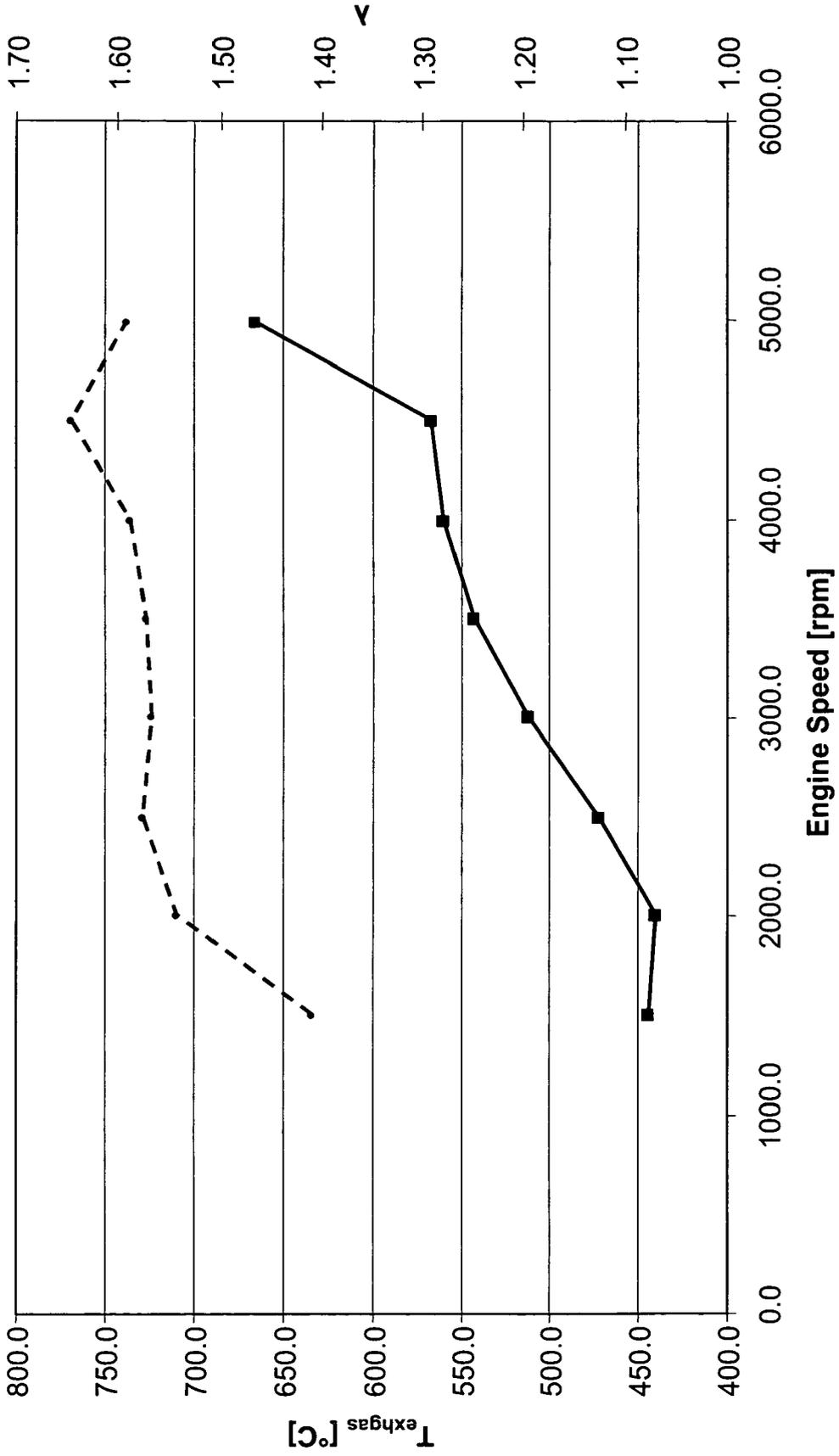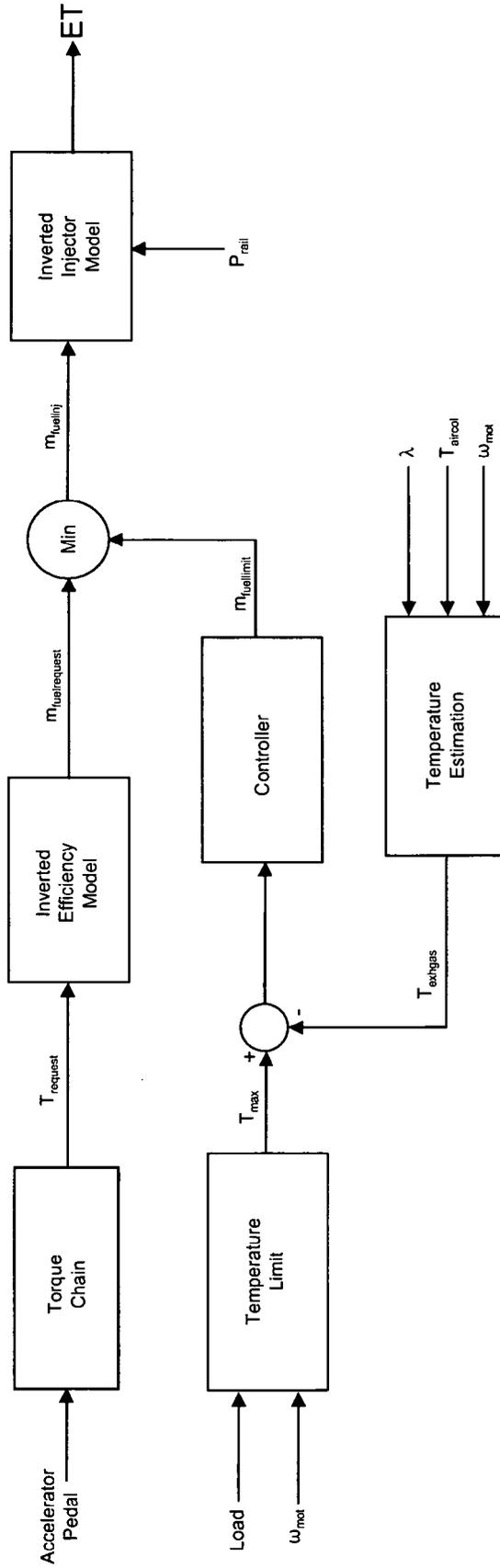Fig. 3

European Patent
Office

PARTIAL EUROPEAN SEARCH REPORT

which under Rule 63 of the European Patent Convention
shall be considered, for the purposes of subsequent
proceedings, as the European search report

Application Number

EP 08 42 5252

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 1 329 627 A (BAYERISCHE MOTOREN WERKE AG [DE]; SIEMENS AG [DE]) 23 July 2003 (2003-07-23) * page 1, line 14 - line 16 * * paragraph [0004] * -----	1,2,4-11	INV. F02D41/24
X	DE 44 33 631 A1 (BOSCH GMBH ROBERT [DE]) 28 March 1996 (1996-03-28) * column 1, line 57 - column 2, line 7 * -----	1,2,4-11	
X	US 6 295 808 B1 (GRIFFIN JOSEPH R [US] ET AL) 2 October 2001 (2001-10-02) * column 3, line 1 - line 3 * -----	1,2,4-11	
X	WO 02/18935 A (HERAEUS ELECTRO NITE INT [BE]) 7 March 2002 (2002-03-07) * page 3, line 18 - line 22 * * page 4, line 4 - line 5 * -----	1,2,4-11	

TECHNICAL FIELDS SEARCHED (IPC)

F02D

INCOMPLETE SEARCH

The Search Division considers that the present application, or one or more of its claims, does/do
not comply with the EPC to such an extent that a meaningful search into the state of the art cannot
be carried out, or can only be carried out partially, for these claims.

Claims searched completely :

Claims searched incompletely :

Claims not searched :

Reason for the limitation of the search:

see sheet C

Place of search	Date of completion of the search	Examiner
Munich	29 September 2008	Jackson, Stephen

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

EPO FORM 1503 03.82 (P04E07)

European Patent Office

**INCOMPLETE SEARCH
SHEET C**

Application Number

EP 08 42 5252

Claim(s) not searched:
    3

Reason for the limitation of the search:

Claim 3 describes the event that an increase in air fuel ratio (or lambda value) results in a decrease of exhaust gas temperature (an inverse proprortion).
Firstly, this describes a physical result achieved by altering the air fuel ratio (or lambda value), and cannot be considered as an invention. The claim does not appear to define neither technical features above those in claim 1, nor a general inventive concept. As a result doesn not fulfil the requirements of Article 84 EPC.
Secondly, the physical relationship described appears to contradict general theory of engine technology. From his own experiences, the examiner is aware that an increase in air fuel ratio (or lambda value) leads to an increase in exhaust temperature (as there is less cooling effect from the fuel) up to a point at which misfire occurs, whereby the temperature then drops due to a lack of combustion. Accordingly, this relationship is used to increase catalyst temperature when regeneration thereof is required. The opposite effect (a decrease in AFR leading to a decrease in exhaust gas temperature) is used for catalyst protection at high speed and load conditions, and for the prevention of detonation, as the increase in fuel mass acts to cool the charge and exhaust gasses. It appears that claim 3 defines subject matter relating to an engine which does not operate according to general engine theory without any explanation as to how this is done. As a result, the subject matter of claim 3 is unclear, and cannot be searched.

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

EP 08 42 5252

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

29-09-2008

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP 1329627	A	23-07-2003	DE	10201465 A1	07-08-2003
DE 4433631	A1	28-03-1996	IT	MI951890 A1	21-03-1996
			JP	3670727 B2	13-07-2005
			JP	8114513 A	07-05-1996
			US	5647668 A	15-07-1997
US 6295808	B1	02-10-2001	NONE		
WO 0218935	A	07-03-2002	NONE		

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82