SYSTEM AND METHOD FOR DIAGNOsing THE SELECTIVE CATALYTIC REDUCTION SYSTEM OF A MOTOR VEHICLE

Abstract

A system and method for diagnosing selective catalytic reduction system of a motor vehicle, the system including an internal combustion engine connected by an exhaust manifold to, successively, an assembly including a nitrogen oxide catalyst and a particle filter and a selective catalytic reduction system, a mechanism draining mass of ammonia stored in the selective catalytic reduction system, a mechanism controlling draining, and a mechanism injecting urea positioned upstream of the selective catalytic reduction system, a mechanism measuring quantity of ammonia at an outlet of the selective catalytic reduction system, a system determining maximum mass of ammonia stored in the selective catalytic reduction system, and a comparison mechanism configured to transmit a fault signal based on a result of a comparison between the maximum mass of ammonia stored in the selective catalytic reduction system and a threshold.
FIG. 2

FIG. 3

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SYSTEM AND METHOD FOR DIAGNOSING THE SELECTIVE CATALYTIC REDUCTION SYSTEM OF A MOTOR VEHICLE

[0001] The area of the invention is the on-board diagnosis of functions of a motor vehicle, more particularly the diagnosis of the catalytic reduction of polluting emissions of a diesel-type motor vehicle.

[0002] In order to respond to the lower limits for the permitted emission of pollutants from motor vehicles, increasingly complex exhaust gas after-treatment systems are provided in the exhaust tract of lean-burn engines. These allow reduction in particular of the emissions of particulates and nitrous oxides, as well as carbon monoxide and unburnt hydrocarbons.

[0003] The selective catalytic reduction system (SCR) is known as an effective means for treatment for nitrous oxides (NO₂). The system comprises continuous treatment of nitrous oxide emissions (nitrates and nitrates). It requires the use of a catalyst and a reducing agent injector arranged in the exhaust system.

[0004] The system therefore requires the addition of an additional tank containing the reducing agent (AdBlue for example), the specific injection system, a system for mixing the reducing agent with the exhaust gases, and a catalyst system accelerating the reduction of nitrous oxides by the reducing agent injected and/or stored on the catalyst. It is noted that, in order to optimize the efficiency of nitrous oxide treatment, the mixture entering the catalyst of the selective catalytic reduction system SCR must be as homogenous as possible, which requires the use of the abovementioned mixing system.

[0005] In this system, the quantity of reducing agent injected and the quantity of reducing agent stored on the catalyst must be finely adapted: in fact, an overdose of reducing agent (stored or injected) would only pointless increase the consumptions of reducing agent and perhaps generate emissions of ammonia at the exhaust (a highly odorous and highly toxic compound). Under-dosing however limits the efficiency obtained and hence increases the emissions of nitrous oxides at the exhaust.

[0006] Chemically, the selective catalytic reduction system stores the ammonia (NH₃) contained in the reducing agent, such as urea. The ammonia thus stored in the selective catalytic reduction system then reduces the nitrous oxides (NO₂).

For optimum efficiency of the selective catalytic reduction system, it is necessary to control the stored mass of ammonia (NH₃), also called the ammonia buffer (NH₃). However, as the selective catalytic reduction system ages, its ammonia storage capacity (NH₃) degrades, leading to a loss of efficiency.

[0007] Euro 5 and Euro 6 standards impose an on-board diagnosis (OBD) system for the entire selective catalytic reduction system. This therefore requires recurrent verification that the selective catalytic reduction system remains sufficiently effective at treating nitrous oxides (NO₂) to meet the on-board diagnosis thresholds. Until now, diagnosis of the selective catalytic reduction system SCR has been based on the degradation of efficiency of the treatment of nitrous oxides (NO₂).

[0008] However, it is not possible at present to diagnose the loss of storage capacity for the ammonia (NH₃) which is a more direct consequence of ageing. The main difficulty of the new diagnostic method is that it must be able to discriminate between a reversible efficiency loss, which is compensated for example by adapting the control of the urea injection, from a definitive loss when the SCR no longer has any storage sites for ammonia NH₃ for treating the nitrous oxides NO₂. This requires diagnosis of the ammonia storage capacity (ASC), a value characterized by a maximum mass of ammonia (NH₃) which can be stored, which is a direct reflection of the ageing state of the SCR.

[0009] From the prior art, the following documents are known.

[0010] Document WO 2008/103113 discloses an on-board diagnosis (OBD) of the SCR system based on the efficiency of the treatment of nitrous oxides NO₂ under specific conditions. The efficiency of treatment of the nitrous oxides NO₂ by the selective catalytic reduction system SCR greatly depends on the NO₂/NOₓ ratio between the nitrogen dioxide and the nitrous oxides at the inlet to the selective catalytic reduction system SCR. This ratio cannot be measured and is affected by the sulphurization level of the catalyst DOC, and by the soot level of the particulate filter FAP upstream of the selective catalytic reduction system SCR. The efficiency determined by the model of the on-board selective catalytic reduction system SCR is compared with that determined via a sensor for nitrous oxides NO₂ arranged downstream of the selective catalytic reduction system SCR, under conditions where the NO₂/NOₓ ratio is a priori nominal, i.e., after desulphurization of the catalyst DOC and/or regeneration of the particulate filter FAP. If, under nominal conditions, the efficiency measured is less than the efficiency calculated by the model, a failure of the selective catalytic reduction system SCR is detected.

[0011] Document WO 2007/037730 discloses a diagnosis system for the selective catalytic reduction system SCR based on comparison of the efficiency of the treatment of the nitrous oxides NO₂ by a nitrous oxides NO₂ sensor arranged downstream of the selective catalytic reduction system SCR, with a nominal efficiency at a given engine operating point (load, speed). If the efficiency of the SCR is lower than the reference, a failure is detected.

[0012] There is therefore a need for a system and a method for diagnosis of the selective catalytic reduction system taking into account the loss of ammonia storage capacity, a direct consequence of ageing.

[0013] An object of the invention is a system for diagnosing the selective catalytic reduction system of a motor vehicle equipped with an internal combustion engine connected via an exhaust manifold successively to an assembly comprising a nitrous oxide catalyst and a particulate filter, and a selective catalytic reduction system. The system comprises:

[0014] a means for evacuation of the ammonia mass stored in the selective catalytic reduction system,
[0015] a urea injection means arranged upstream of the selective catalytic reduction system,
[0016] a means for control of the evacuation and injection,
[0017] a means for measuring the quantity of ammonia at the outlet from the selective catalytic reduction system,
[0018] a system for determining the maximum mass of ammonia stored in the selective catalytic reduction system,
[0019] a means for comparing the value determined for the maximum mass of ammonia stored in the selective catalytic reduction system with a threshold, and able to emit a fault signal as a function of the comparison result.
The means for determining the maximum mass of ammonia stored in the selective catalytic reduction system may comprise a means for determining the ammonia level at the outlet from the selective catalytic reduction system as a function of the signal received from the measuring means, and a means for modeling the selective catalytic reduction system, and able to estimate the levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system via a model. The means for determining the maximum mass may also comprise a calculation means able to determine the difference between the level of ammonia measured at the outlet from the selective catalytic reduction system and the modeled values for the levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system, and to determine a new value for the maximum mass of ammonia stored in the selective catalytic reduction system if the difference is positive, and to transmit the new value for the maximum mass of ammonia stored in the selective catalytic reduction system to the means for modeling the selective catalytic reduction system in order to determine new values until the difference is zero. The calculation means may be able to transmit the maximum mass of ammonia stored in the selective catalytic reduction system when the difference is zero.

The fault signal for the selective catalytic reduction system may assume a first value if the value determined for the maximum mass of ammonia stored in the selective catalytic reduction system is less than a threshold, while it assumes a second value if this is not the case. The means for modeling the selective catalytic reduction system may be able to estimate the ammonia level downstream of the selective catalytic reduction via a model, as a function of the ratio between the nitrogen dioxide and the nitrous oxides downstream of the exhaust manifold, the temperature upstream of the selective catalytic reduction system, the mass of urea injected upstream of the selective catalytic reduction system, the maximum mass of ammonia stored in the selective catalytic reduction system, the exhaust gas flow, the level of ammonia upstream of the selective catalytic reduction system, and the level of nitrous oxides upstream of the selective catalytic reduction system.

The means for modeling the selective catalytic reduction system may also be able to determine the ratio between nitrogen dioxide and nitrogen monoxide downstream of the exhaust manifold, as a function of the temperature upstream of the assembly of the particulate filter and the catalyst, the exhaust gas flow from the internal combustion engine, and the level of nitrous oxides downstream of the exhaust manifold. Another object of the invention is a method for diagnosing the selective catalytic reduction system of a motor vehicle equipped with an internal combustion engine connected via an exhaust manifold successively to an assembly comprising a nitrous oxide catalyst and a particulate filter, and a selective catalytic reduction system. The method comprises the following steps:

1. Determination of the maximum mass of ammonia stored in the selective catalytic reduction system.
2. Injection, upstream of the selective catalytic reduction system, of a mass of urea greater than the maximum mass which can be stored by the selective catalytic reduction system.
3. Evacuation of the ammonia mass stored in the selective catalytic reduction system.
4. Emission of a fault signal as a function of comparison of the value determined for the maximum mass of ammonia stored in the selective catalytic reduction system with a threshold.
5. Initialization of a model with a saved value for the maximum mass which can be stored in the selective catalytic reduction system.
6. Estimation of the levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system via a model.
7. Measurement of the ammonia level at the outlet from the selective catalytic reduction system.
8. Determination of the difference between the ammonia level at the outlet from the selective catalytic reduction system and the modeled values for the levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system.
9. If the difference is positive, determination of a new value for the maximum mass of ammonia stored in the selective catalytic reduction system, and determination of new values for the levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system via the model until the difference is zero.
10. When the difference is zero, the value of the maximum mass stored in the selective catalytic reduction system is emitted.

If the value determined for the maximum mass of ammonia stored in the selective catalytic reduction system is less than a threshold, a fault signal assuming a first value may be emitted for the selective catalytic reduction system, while it assumes a second value if this is not the case. The levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system may be estimated via a model as a function of the ratio between the quantity of nitrogen monoxide and nitrogen dioxide downstream of the exhaust manifold, the temperature upstream of the selective catalytic reduction system, the mass of urea injected upstream of the selective catalytic reduction system, the maximum mass of ammonia stored in the selective catalytic reduction system, the exhaust gas flow, the level of ammonia upstream of the selective catalytic reduction system, and the level of nitrous oxides upstream of the selective catalytic reduction system.

The ratio between the nitrogen monoxide and the nitrogen dioxide downstream of the exhaust manifold may be determined as a function of the temperature upstream of the assembly of the particulate filter and the catalyst, the exhaust gas flow from the internal combustion engine, and the level of nitrous oxides downstream of the exhaust manifold.

Further aims, characteristics and advantages will appear from reading the description below, given solely as a non-limitative example, and with reference to the attached drawings on which:

1. FIG. 1 shows the principal elements of an internal combustion engine equipped with a selective catalytic reduction system and an on-board diagnostic system.
2. FIG. 2 illustrates the main elements of a system for determining the maximum ammonia storage capacity, and
3. FIG. 3 illustrates the main steps of the method for diagnosing the selective catalytic reduction system.
FIG. 1 illustrates an internal combustion engine 1 of a motor vehicle connected by its exhaust pipe to an exhaust pipe. Mounted on the exhaust pipe downstream of the exhaust manifold, we see successively a first temperature sensor 2, an assembly 3 comprising an oxidation catalyst and a particulate filter, a urea injector 4, a second temperature sensor 5, a selective catalytic reduction system 6 and a nitrous oxide sensor 7.

Preferably, the oxidation catalyst is housed in the assembly 3 upstream of the particulate filter, i.e. closer to the engine 1, so as to reach its ignition temperature more quickly. Also preferably, the second temperature sensor 5 is installed upstream of the injector 4, such that the temperature measurement is not disrupted by the urea injection.

The internal combustion engine 1 is connected directly or via a control means to an on-board diagnostic system 8 via a connection providing the exhaust gas flow and the flow of nitrous oxides NOx. These flows result from a map or from an estimation means, depending in particular on the operating point of the internal combustion engine 1.

The first temperature sensor 2 is connected to the on-board diagnostic system 8 via a connection 2a providing the temperature upstream of the assembly 3. The second temperature sensor 5 is connected to the on-board diagnostic system 8 via a connection 5a providing the temperature upstream of the selective catalytic reduction system 6.

The nitrous oxides sensor 7 is connected to the on-board diagnostic system 8 via a connection 7a providing the quantity of nitrous oxides and ammonia downstream of the selective catalytic reduction system 6.

To diagnose the selective catalytic reduction system (SCR), the maximum mass of ammonia stored is estimated under conditions of leakage of this ammonia. The nitrous oxides (NOx) sensor, reference 7, arranged downstream of the selective catalytic reduction system 6, cannot distinguish nitrous oxides (NOx) from ammonia (NH3). This property can then be exploited to detect leaks of ammonia (NH3), deduced from this the maximum mass of ammonia stored, and diagnose a failure as a function of this value.

However, to estimate the maximum mass of ammonia stored, it is necessary to estimate the mass of ammonia stored at a given instant as a function of a model of the selective catalytic reduction system 6. The model described below is included in the system 9 for determining the maximum ammonia storage capacity. To be able to estimate the maximum mass of ammonia stored, the model is linked to the nitrous oxides NOx sensor, reference 7.

Also, to determine the maximum mass of ammonia stored, the selective catalytic reduction system is evacuated via a control means 8b for the evacuation and injection of urea, linked to an actuator via connection 6a. Alternatively, the control means 8b may interrupt the urea injection by the injector 4 in order to obtain an effect equivalent to evacuation by consumption of all the ammonia present in the selective catalytic reduction system. Since evacuation allows an absolute reference value to be set, the mass determined does not comprise any relativity and can therefore be compared with a threshold by a comparison means 8b in order to determine a failure of the selective catalytic reduction system.

The description presented below firstly comprises presentation of the modeling of the selective catalytic reduction system 6, then the method and system of diagnosing the selective catalytic reduction system.

FIG. 2 illustrates a system 9 for determining the maximum ammonia storage capacity. This has a means 9a for determining the ammonia level at the outlet from the selective catalytic reduction system 6, as a function of the measurement by the nitrous oxides sensor 7.

There is a means 9b for modeling the selective catalytic reduction system. The modeling of the selective catalytic reduction system begins by estimating the ammonia mass. This is given by a reduced model based on the physico-chemical phenomena taking place in the exhaust tract.

The ratio α between the nitrogen dioxide (NO2) and the nitrous oxides (NOx), imposed by the combination of the oxidation catalyst (DOC) and the particulate filter (FAP) at the inlet to the selective catalytic reduction system 6, has a great influence on the efficiency of the selective catalytic reduction system.

However, this ratio α between the nitrogen dioxide (NO2) and the nitrous oxides (NOx) cannot be measured. It must therefore be estimated via a model or map as a function of the exhaust gas flow Qexh and the temperature at the inlet to the oxidation catalyst (DOC), called Tdoc. The exhaust gas flow Qexh is measured or modeled as a function of the different engine gas flows.

We can then determine the level of nitrogen monoxide XNO1 and nitrogen dioxide XNO2 at the inlet to the selective catalytic reduction system as a function of the level of nitrous oxides (NOx) at the outlet from the engine Xout and the ratio between the nitrogen dioxide (NO2) and the nitrous oxides (NOx), called α. The following equation explains this determination.

\[ X_{\text{NO1}} = \alpha(T_{\text{DOC}}, Q_{\text{exh}}) X_{\text{out}} \]

\[ X_{\text{NO2}} = (1 - \alpha(T_{\text{DOC}}, Q_{\text{exh}})) X_{\text{out}} \]

(Eq. 1)

It is noted that the level of nitrous oxides (NOx) at the outlet from the engine Xout can be measured via a sensor or estimated via a model.

The simplified reactional mechanism below reflects the function of the selective catalytic reduction system:

\[ \text{NH}_3 + \text{NO} \rightarrow \text{NH}_4\text{NO}_2 \]

\[ \text{NH}_3 + \text{O}_2 \rightarrow \text{N}_2 + \text{H}_2\text{O} \]

Wherein:

*: is a site which can receive a molecule of ammonia NH3

NH3*: represents a stored molecule of ammonia NH3

O2: a molecule of dioxygen

N2*: a molecule of dinitrogen

NO: a molecule of nitrogen monoxide

NO2: a molecule of nitrogen dioxide.

It is possible to model the reactional mechanism described below in order to obtain dynamically the level
X^{out\ max}_{nh3} of nitrous oxides (NOx) and the level X^{out\ nh3}_{nh3} of ammonia (NH3) downstream of the selective catalytic reduction system, and the stored mass m_{nh3} (also called the buffer) of ammonia (NH3) as a function of the level X^{in\ max}_{nh3} of nitrous oxides (NOx) and the level X^{out\ nh3}_{nh3} of ammonia (NH3) upstream of the selective catalytic reduction system, the exhaust gas flow q_{eh}, the temperature T_{eh} of these gases at the inlet to the selective catalytic reduction system, and finally the maximum mass of ammonia stored in the selective catalytic reduction system, called m^{max\ nh3}_{nh3}\.

[0063] The equation system illustrates such a model.

\[
\frac{dm_{nh3}}{dt} = f(X_{nh3}^{in}, X_{nh3}^{out}, m_{nh3}, T_{eh}, q_{eh}, \alpha, m_{nh3}^{max}) \quad \text{(Eq. 3)}
\]

\[
X_{nh3}^{out} = h_{nh3}(X_{nh3}^{in}, X_{nh3}^{out}, m_{nh3}, T_{eh}, q_{eh}, \alpha, m_{nh3}^{max})
\]

\[
X_{nh3}^{in} = h_{nh3}(X_{nh3}^{in}, X_{nh3}^{out}, m_{nh3}, T_{eh}, q_{eh}, \alpha, m_{nh3}^{max})
\]

Wherein:

\[
\text{K: strictly positive gain}
\]

[0064] By combining equations 3 and 4, we propose the following observer:

\[
\frac{dm_{nh3}}{dt} = f(X_{nh3}^{in}, X_{nh3}^{out}, m_{nh3}, T_{eh}, q_{eh}, \alpha, m_{nh3}^{max})
\]

\[
X_{nh3}^{out} = h_{nh3}(X_{nh3}^{in}, X_{nh3}^{out}, m_{nh3}, T_{eh}, q_{eh}, \alpha, m_{nh3}^{max})
\]

\[
X_{nh3}^{in} = h_{nh3}(X_{nh3}^{in}, X_{nh3}^{out}, m_{nh3}, T_{eh}, q_{eh}, \alpha, m_{nh3}^{max})
\]

Wherein:

\[
\Delta X_{nh3}^{out} = \Delta X_{nh3}^{in} - X_{nh3}^{out} - X_{nh3}^{out}\quad \text{(Eq. 6)}
\]

K: strictly positive gain

[0065] With reference still to FIG. 2, we see that the means 9b for determining the selective catalytic reduction system determines the variation in mass dm_{nh3}/dt of ammonia (NH3) as a function of time, the level X^{out\ max}_{nh3} of nitrous oxides (NOx) and the level X^{out\ nh3}_{nh3} of ammonia (NH3) downstream of the selective catalytic reduction system, as a function of the level X^{in\ max}_{nh3} of nitrous oxides (NOx) upstream of the selective catalytic reduction system and the flow q_{eh}, of exhaust gas from the internal combustion engine 1, the temperature T_{eh} of these gases at the inlet to the selective catalytic reduction system from the second temperature sensor 5, the ratio \alpha between the nitrogen dioxide (NO2) and the nitrous oxides (NOx), the maximum mass m^{max\ nh3}_{nh3} of ammonia stored in the selective catalytic reduction system, the level X^{in\ nh3}_{nh3} of ammonia (NH3) upstream of the selective catalytic reduction system, and the current mass m_{nh3} of ammonia stored in the selective catalytic reduction system. It is noted that the maximum mass m^{max\ nh3}_{nh3} of ammonia stored in the selective catalytic reduction system is a datum for design of the selective catalytic reduction system 6.

[0066] By knowing the variation in mass of ammonia over time dm_{nh3}/dt, the level X^{out\ max}_{nh3} of nitrous oxides (NOx) and the level X^{out\ nh3}_{nh3} of ammonia (NH3) downstream of the selective catalytic reduction system, it is possible to determine the maximum mass of ammonia stored via an observer. Prior to definition of the observer, the measurement from the nitrous oxides sensor (NOx) downstream of the selective catalytic reduction system is broken down to take account of its capacity to measure both nitrous oxides and ammonia. The following equation takes into account this breakdown.

\[
\Delta X_{nh3}^{out} = \Delta X_{nh3}^{in} - X_{nh3}^{out} - X_{nh3}^{out}\quad \text{(Eq. 4)}
\]

Wherein:

\[
X^{out\ max}_{nh3}: \text{value of the measurement of the nitrous oxides sensor}
\]

\[
X^{out\ max}_{nh3}: \text{level of nitrous oxides}
\]

\[
X^{out\ nh3}_{nh3}: \text{level of ammonia (NH3) downstream of the selective catalytic reduction system.}
\]

[0067] This distribution between two contributions, as has been described above, reflects the fact that it is not possible to distinguish between nitrous oxides (NOx) and ammonia (NH3) at the selective catalytic reduction system.

[0068] On FIG. 2, we can see that the system 9 for determining the maximum ammonia storage capacity also comprises a subtractor 9c connected at the inlet to the means 9d for determining the ammonia level at the outlet from the selective catalytic reduction system 6, and to the means 9e for modeling the selective catalytic reduction system, and connected at the outlet to a calculation means 9f able to determine the maximum mass m^{max\ nh3}_{nh3} of ammonia stored in the selective catalytic reduction system as a function of the signal received from the subtractor 9c and from a memory 9e.

[0069] The subtractor 9c allows determination of the parameter \Delta by application of equation 6, by subtracting the values received from the means 9b for modeling the selective catalytic reduction system from the value received from the determination means 9a.

[0070] The calculation means 9d determines the maximum mass m^{max\ nh3}_{nh3} of ammonia stored in the selective catalytic reduction system as a function of the signal received from the memory 9e when the system 9 for determining the maximum ammonia storage capacity is initialized. In other situations, the calculation means 9d determines the maximum mass m^{max\ nh3}_{nh3} of ammonia stored in the selective catalytic reduction system by integrating, relative to time, the product of parameter \Delta by the saved constant K. In doing this, the calculation means 9d applies the third equation of the equation system (Eq. 5).

[0071] The calculation means 9d also estimates whether the parameter \Delta is zero. If so, the calculation means 9d emits the determined value for the maximum mass m^{max\ nh3}_{nh3} of ammonia stored in the selective catalytic reduction system.

[0072] The comparison means 8b receives from the calculation means 9d a signal carrying the maximum mass m^{max\ nh3}_{nh3} of ammonia stored in the selective catalytic reduction system 6. The comparison means 8b performs the comparison of the maximum mass with a memorized threshold, allowing a distinction between a selective catalytic reduction system in good condition and a faulty selective catalytic reduction system. If the maximum mass is greater than the threshold, a signal for absence of failure is transmitted, otherwise a failure signal is transmitted. Alternatively, only the failure signal is emitted, and only when the emission conditions are combined.

[0073] Use of the observer described above will be better understood from reading the numerical example below.

[0074] Let us assume that the maximum mass of ammonia which can be stored in a selective catalytic reduction system in good condition is equal to 4 g.
Also, as we are in leakage conditions for ammonia (NH₃), we can ignore the nitrous oxides (NOₓ) at the outlet from the selective catalytic reduction system. In fact the nitrous oxides will be reduced by the excess of ammonia (NH₃).

The model is initialized with a maximum m_{nh3}^max of ammonia stored in the catalyst equal to the value of the maximum mass of ammonia which can be stored in a selective catalytic reduction system in good condition, or 4 g in the present example, then the values for the level of nitrous oxides and ammonia (NH₃) downstream of the selective catalytic reduction system are determined.

Then we determine the value of parameter Δ as a function of the modeled values for the levels of nitrous oxides and ammonia (NH₃) downstream of the selective catalytic reduction system, and of the measurement from the nitrous oxides sensor.

If parameter Δ is positive, the maximum mass m_{nh3}^max of ammonia stored in the catalyst is less than the maximum mass with which the selective catalytic reduction system was modeled.

We then determine a new maximum mass as a function of the parameter Δ determined. The new maximum mass is re-injected at the inlet to the model, such that we determine new values for the levels of nitrous oxides and ammonia (NH₃) downstream of the selective catalytic reduction system.

These new values are then compared with the measurement of the nitrous oxides level at the outlet from the selective catalytic reduction system, in order to determine a new value for parameter Δ. If parameter Δ is positive, the method continues by determining new values for the maximum mass m_{nh3}^max of ammonia stored in the catalyst, and the levels of nitrous oxides and ammonia (NH₃) downstream of the selective catalytic reduction system, until we obtain a value of zero for parameter Δ.

As soon as parameter Δ is zero, the current value of the maximum mass m_{nh3}^max of ammonia stored in the catalyst is saved and compared with a threshold. If the value is greater than the threshold, the selective catalytic reduction system is in good condition, otherwise a fault is detected and a warning signal emitted.

The method for diagnosing the selective catalytic reduction system illustrated by FIG. 3 uses the model and equations explained above.

The method comprises a first step 10 during which the ammonia mass is evacuated. In fact, in order to perform the diagnosis under the best conditions, an evacuation is performed so that the estimate of the maximum mass m_{nh3}^max of ammonia stored in the selective catalytic reduction system can begin from an absolute reference substantially equal to zero. This evacuation takes place by cutting the urea injection for a few minutes.

During the second step 11, a specific mass of urea is injected which is sufficiently high for the selective catalytic reduction system to either reach or exceed the limit for leakage of ammonia (NH₃). In other words, more ammonia (NH₃) is injected than the system can theoretically contain. The mass to be injected may be determined as a function of the maximum mass of ammonia stored in a catalytic reduction system having no fault.

During a third step 12, we estimate the ammonia level x_{nh3}^max and the nitrous oxides level x_{nox}^max downstream of the selective catalytic reduction system via the model by applying equation 5. We also measure the level x_{nh3, opt}^max of ammonia downstream of the selective catalytic reduction system via the nitrous oxides sensor 7. We then determine parameter Δ by applying equation 6. If parameter Δ is positive, a new value is determined for the maximum mass m_{nh3}^max of ammonia stored in the selective catalytic reduction system as a function of the value of the parameter Δ. New values are then determined for the level of ammonia x_{nh3}^opt and nitrous oxides x_{nox} opt downstream of the selective catalytic reduction system via the model before determining a new value for parameter Δ.

The third step is repeated until the value of parameter Δ is zero. The last value of the maximum mass m_{nh3}^max of ammonia stored in the selective catalytic reduction system is then saved.

During a fourth step 13, we compare the maximum mass m_{nh3}^max of ammonia stored in the selective catalytic reduction with a threshold. If the maximum mass is greater than the threshold, the selective catalytic reduction system has no fault. If this is not the case, the selective catalytic reduction system has a fault.

A signal corresponding to the state of the selective catalytic reduction system is then transmitted at the outlet.

1-10. (canceled)

11: A system for diagnosing selective catalytic reduction system of a motor vehicle including an internal combustion engine connected via an exhaust manifold successively to an assembly including a nitrous oxide catalyst and a particulate filter, and a selective catalytic reduction system, the system comprising:

- a means for evacuation of ammonia mass stored in the selective catalytic reduction system;
- a urea injection means arranged upstream of the selective catalytic reduction system;
- a means for control of the evacuation and injection;
- a means for measuring quantity of ammonia at an outlet from the selective catalytic reduction system;
- a system for determining maximum mass of ammonia stored in the selective catalytic reduction system;
- a means for comparing a value determined for the maximum mass of ammonia stored in the selective catalytic reduction system with a threshold, and to emit a fault signal as a function of the comparison result.

12: The system as claimed in claim 11, wherein the means for determining the maximum mass of ammonia stored in the selective catalytic reduction system comprises:

- a means for modeling the selective catalytic reduction system, and to estimate levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system via a model;
- a means for determining a level of ammonia at the outlet from the selective catalytic reduction system as a function of the signal received from the measurement means;
- a calculation means configured to determine a difference between the level of ammonia measured at the outlet from the selective catalytic reduction system and modeled values for levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system, to determine a new value for the maximum mass of ammonia stored in the selective catalytic reduction system if the difference is positive, and to transmit the new value for the maximum mass of ammonia stored in the selective catalytic reduction system to the means for
modeling the selective catalytic reduction system to determine new values until the difference is zero; the calculation means configured to emit the maximum mass of ammonia stored in the selective catalytic reduction system when the difference is zero.

13: The system as claimed in claim 11, wherein the fault signal for the selective catalytic reduction system assumes a first value if the value determined for the maximum mass of ammonia stored in the selective catalytic reduction system is less than a threshold, while it assumes a second value if that is not the case.

14: The system as claimed in claim 12, wherein the means for modeling the selective catalytic reduction system is configured to estimate the ammonia level downstream of the selective catalytic reduction system via a model, as a function of the ratio between the nitrogen dioxide and the nitrous oxides downstream of the exhaust manifold, temperature upstream of the selective catalytic reduction system, the mass of urea injected upstream of the selective catalytic reduction system, the maximum mass of ammonia stored in the selective catalytic reduction system, exhaust gas flow, the level of ammonia upstream of the selective catalytic reduction system, and the level of nitrous oxides upstream of the selective catalytic reduction system.

15: The system as claimed in claim 14, wherein the means for modeling the selective catalytic reduction system is configured to determine the ratio between nitrogen dioxide and nitrogen monoxide downstream of the exhaust manifold, as a function of temperature upstream of the assembly of the particulate filter and the catalyst, exhaust gas flow of the internal combustion engine, and level of nitrous oxides downstream of the exhaust manifold.

16: A method for diagnosing a selective catalytic reduction system of a motor vehicle including an internal combustion engine connected via an exhaust manifold successively to an assembly including a nitrous oxide catalyst and a particulate filter, and a selective catalytic reduction system, the method comprising:

- evacuation of ammonia mass stored in the selective catalytic reduction system;
- injection, upstream of the selective catalytic reduction system, of a mass of urea greater than a maximum mass which can be stored by the selective catalytic reduction system;
- determination of the maximum mass of ammonia stored in the selective catalytic reduction system; and
- emission of a fault signal as a function of a result of comparison of a value determined for the maximum mass of ammonia stored in the selective catalytic reduction system with a threshold.

17: The method as claimed in claim 16, wherein the maximum mass of ammonia stored in the selective catalytic reduction system is determined by performing:

- initialization of a model with a saved value for the maximum mass which can be stored in the selective catalytic reduction system;
- estimation of levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system via a model;
- measurement of an ammonia level at the outlet from the selective catalytic reduction system;
- determination of a difference between the ammonia level at the outlet from the selective catalytic reduction system and the modeled values for the levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system; and

- if the difference is positive, determination of a new value for the maximum mass of ammonia stored in the selective catalytic reduction system, and determination of new values for the levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system via the model until the difference is zero;

- when the difference is zero, a value of the maximum mass stored in the selective catalytic reduction system is emitted.

18: The method as claimed in claim 16, wherein if the value determined for the maximum mass of ammonia stored in the selective catalytic reduction system is less than a threshold, a fault signal assuming a first value is emitted for the selective catalytic reduction system, while it assumes a second value if this is not the case.

19: The method as claimed in claim 17, wherein the levels of ammonia and nitrous oxides downstream of the selective catalytic reduction system are estimated via a model, as a function of the ratio between the quantity of nitrogen monoxide and nitrogen dioxide downstream of the exhaust manifold, the temperature upstream of the selective catalytic reduction system, the mass of urea injected upstream of the selective catalytic reduction system, the maximum mass of ammonia stored in the selective catalytic reduction system, exhaust gas flow, the level of ammonia upstream of the selective catalytic reduction system, and the level of nitrous oxides upstream of the selective catalytic reduction system.

20: The method as claimed in claim 19, wherein the ratio between the nitrogen monoxide and the nitrogen dioxide downstream of the exhaust manifold is determined as a function of the temperature upstream of the assembly of the particulate filter and the catalyst, exhaust gas flow from the internal combustion engine, and the level of nitrous oxides downstream of the exhaust manifold.