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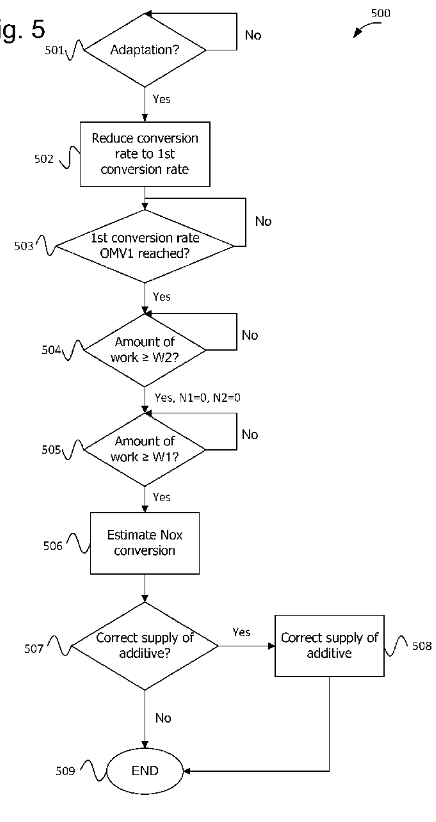
[Continued on next page]

(54) Title: METHOD AND SYSTEM FOR ADAPTATION OF SUPPLY OF ADDITIVE TO AN EXHAUST GAS STREAM

Fig. 5



(57) Abstract: The present invention concerns a method for correcting a supply of a first additive for reducing at least a first substance (NO_x) present in an exhaust gas stream. The method comprises, in connection with said correction: - determination of a first accumulation (N1) of a representation of said first substance (NO_x), wherein said first accumulation (N1) of said first substance (NO_x) represents an accumulated amount of said first substance (NO_x) downstream of said supply of said first additive; - determination as to whether a first amount of work (W1) has been performed by said combustion engine (101) during the accumulation of said first substance (NO_x); - discontinuation of said first accumulation of said first substance (NO_x) when said first amount of work (W1) has been performed by said combustion engine (101); and - correction of the supply of said first additive based on said first accumulation (N1) of said first substance (NO_x).

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METHOD AND SYSTEM FOR ADAPTATION OF SUPPLY OF ADDITIVE TO AN EXHAUST GAS STREAM

Technical field of the invention

The present invention concerns an exhaust gas purification system, and in particular a method for correcting the supply of additive to an exhaust gas stream according to the preamble to claim 1. The invention also concerns a system and a vehicle, as well as a computer program and a computer program product, which implement the method according to the invention.

Background of the invention

Because of, for example, increased government interest in pollutants and air quality in, for example, urban areas, emissions standards and regulations have been formulated in many jurisdictions.

Such emissions standards often include sets of requirements that define acceptable limits for exhaust gas emissions from vehicles equipped with combustion engines. For example, emission levels for nitrogen oxides (NO_x), carbohydrates (HC), carbon monoxide (CO) and particles are often regulated for most types of vehicles in such standards.

Undesired emissions can, for example, be reduced by reducing fuel consumption and/or via post-treatment (purification) of the exhaust gases produced by combustion in the combustion engine.

Exhaust gases from a combustion engine can, for example, be post-treated through the use of a so-called catalytic purification process. Different types of catalytic converters exist, and different types may be required for various fuels and/or to purify different types of exhaust gas components, and, in the case of at least nitrogen oxides NO_x (such as NO and nitrogen dioxide, NO_2), heavy vehicles often contain a catalytic converter in which an additive is supplied to the exhaust gas stream from the combustion in the combustion engine in order to reduce nitrogen oxides NO_x (into mainly nitrogen gas and water vapor).

One commonly occurring type of catalytic converter to which additives are supplied consists of SCR (Selective Catalyst Reduction) catalytic converters. SCR catalytic converters use ammonia (NH_3) or a compound from which ammonia can be generated/formed as an additive to reduce the level of nitrogen oxides NO_x. The additive is injected into the exhaust gas stream resulting from the combustion engine, upstream of the catalytic converter.

The additive supplied to the catalytic converter is absorbed (stored) in the catalytic converter, whereupon nitrogen oxides NO_x in the exhaust gases react with the ammonia stored in the catalytic converter. The capacity of the catalytic converter to store additives usually varies dramatically with the prevailing temperature in the catalytic converter. Larger amounts of ammonia can be stored at lower temperatures, while the storage capacity at higher temperatures is lower.

When supplying an additive, it is important that the amount of additive not be too great or too small. It is thus desirable for the supplied amount of additive to correspond to an anticipated amount of additive.

Summary of the invention

One object of the present invention is to provide a method for correcting a supply of additive to an exhaust gas stream. This object is achieved by means of a method according to claim 1.

The present invention concerns a method for correcting a supply of a first additive for treating an exhaust gas stream resulting from combustion in a combustion engine, wherein said first additive is supplied to said exhaust gas stream, and wherein said first additive is used to reduce at least a first substance present in said exhaust gas stream. The method comprises, during said correction:

- initiation of a first accumulation of a representation of said first substance, wherein said first accumulation of said representation of said first substance represents an accumulated amount of said first substance downstream of said supply of said first additive;
- determination as to whether a first amount of work has been performed by said combustion engine during the accumulation of said first substance;
- discontinuation of said first accumulation of said first substance when said first amount of work has been performed by said combustion engine; and
- correction of a supply of said first additive based on said first accumulation of said first substance.

The presence of at least certain substances in an exhaust gas stream resulting from combustion can be reduced by means of a supply of additive to the exhaust gas stream, whereupon the additive reacts with one or more substances present in the exhaust gas stream so as to thereby form less hazardous substances.

For example, a supply of additive is needed to reduce the concentration of nitrogen oxides NO_x in the exhaust gases from the combustion engine. However, it is important that the additive be supplied in the correct proportions in relation to the substance(s) that are to be reduced. If too small an amount of additive is supplied in relation to the presence, in the exhaust gas stream, of the substance that is to be reduced, an undesired surplus of the substance will prevail, and thus be released into the surroundings of the vehicle, with a risk that permissible limit values will be exceeded.

Conversely, if too large an amount of additive is supplied in relation to the presence of the substance that is to be reduced, there will instead be a risk that other undesirable substances supplied via the additive will be released into the surroundings.

The risk of undesired emissions can be reduced by adapting the supply of additive, i.e. determining whether the supplied amount actually corresponds to the anticipated amount of supplied additive and, if necessary, correcting the supply of additive. However, as is explained below, the supply of additive is normally reduced by such an adaptation, with increased emissions as a result, in connection with which the available adaptation time may be limited.

The present invention provides a method that manages the available adaptation time in an efficient manner, and that also does not take a longer time than necessary. This is achieved by accumulating said first substance over a period of time during which the combustion engine is performing a first amount of work, i.e. when a given amount of work has been performed during ongoing accumulation. This has the advantage that the entire adaptation time can be utilized, and ensuring that a given amount of work is performed by the combustion engine makes it possible to ensure that a representative adaptation is achieved. Furthermore, the accumulation can be carried out independent of the magnitude of the power output by the combustion engine, i.e. the power output by the combustion engine can vary greatly during the accumulation. The accumulation can thus be carried out continuously, independent of the power output by the combustion engine.

Said accumulation can be performed by utilizing signals emitted by a sensor arranged downstream of said supply of said first additive. When said first substance consists of nitrogen oxides NO_x, said first sensor can consist of an NO_x sensor.

As is evident, the accumulation of said first substance according to the invention consists of an accumulation of the amount of said first substance that passes with the exhaust gas stream at the position where the accumulation is carried out. The accumulation thus involves no physical collection of said first substance.

Furthermore, said representation of said first substance comprises a suitable representation of the presence of said first substance in the exhaust gas stream, such as an amount determined by means of sensor signals or an amount estimated by means of a calculating model.

Said first accumulation of said first substance can be arranged so as to be compared with a second amount, whereupon said second amount can represent a presence of said first substance in said exhaust gas stream upstream of said supply of said first additive. The supply of said first additive can then be corrected based on said comparison.

Said comparison can be made by determining a ratio between said first accumulation and said second amount, and comparing said determined ratio with a first ratio. The supply of said first additive can then be corrected based on said comparison. This correction can, for example, consist of determining a correction factor that is applied to the supply of additive, wherein, for example, the injection that is to be performed is multiplied by the correction factor, whereupon the injected amount can be increased or decreased in dependence upon the magnitude of the correction factor.

Said second amount can, for example, be arranged so as to be determined through the use of a sensor arranged upstream of said supply of said first additive, wherein said second amount can consist of an accumulation of said first substance upstream of said supply of said additive, or through the use of a calculation model representing the anticipated presence of said first substance based on the amount of work performed by said combustion engine, whereupon such an accumulation can be carried out through the use of said calculation model.

According to one embodiment, the supply of said first additive to said exhaust gas stream can be reduced before the accumulation of said first substance is initiated, e.g. to some suitable conversion rate with respect to the reduction of said first substance, whereupon the accumulation of said first substance can be initiated a first time after said supply of said first additive has been reduced, or after a suitable amount of work has been performed by said combustion engine since the reduction of said supply of said first additive was initiated. This has the advantage of making it possible to ensure that, for example, a reaction substance supplied by means of said additive and stored in a catalytic converter can be reduced before accumulation is initiated so as to thereby ensure that the stored reaction substance does not falsely influence the estimation according to the invention.

Said first additive can be arranged so as to be supplied upstream of a first catalytic converter, such as an SCR catalytic converter, and wherein said accumulation of said first amount of said first substance consists of an accumulation of said first substance downstream of said first catalytic converter.

Additional characteristics of the present invention and the advantages thereof will be presented in the following detailed description of exemplary embodiments and the accompanying drawings.

Brief description of the drawings

Fig. 1A shows a drivetrain in a vehicle in which the present invention can be used advantageously.

Fig. 1B shows a control unit in a vehicle control system.

Fig. 2 shows an example of a post-treatment system in a vehicle in which the present invention can be used advantageously.

Fig. 3 shows an example of the change in the conversion rate with the supplied additive in connection with conversion of a substance.

Fig. 4 shows an example of how the conversion rate can be changed over time in connection with adaptation of the supply of additive.

Fig. 5 schematically depicts an exemplary method according to one embodiment of the present invention.

Fig. 6 shows an example of the change in the conversion rate over time for an adaptation according to the present invention.

Detailed description of preferred embodiments

The present invention will be exemplified for a vehicle below. However, the invention is also applicable to many types of means of transport, such as aircraft and watercraft, as long as an additive is being added to an exhaust gas stream resulting from combustion.

Furthermore, the term "substance" is used in the present description and accompanying claims and comprises, at least in the present description and accompanying claims, chemical compounds.

Fig. 1A schematically depicts a drivetrain in a vehicle 100 according to one embodiment of the present invention. The vehicle 100 depicted schematically in Fig. 1A comprises a drivetrain with a combustion engine 101, which is connected in a customary manner via a shaft emerging from the combustion engine, usually via a flywheel 102, to a transmission 103 via a clutch 106. The combustion engine 101 is controlled by the control system of the vehicle 100 via an engine control unit 115. In the present example, the clutch 106 and transmission are similarly controlled by a control unit 116.

Furthermore, a shaft 107 emerging from the transmission 103 drives drive wheels 113, 114 via a final drive 108, such as a typical differential, and drive axles 104, 105 connected with said final drive 108. Fig. 1A thus shows a drivetrain of a specific type, but the invention is applicable to all types of drivetrains, and to, for example, hybrid vehicles. The depicted vehicle also comprises a post-treatment system 130 for post-treatment (purification) of the exhaust gases resulting from combustion in the combustion engine. The functions of the post-processing system are controlled by a control unit 131.

The post-processing systems can be of various types and, according to the embodiment shown, additive is supplied to a catalytic exhaust gas purification process. An example of a post-processing system in which the present invention can be applied is shown in greater detail in Fig. 2 and, in the exemplary embodiment shown, the post-processing system includes an SCR (Selective Catalytic Reduction) catalytic converter 201. The post-processing system can also comprise additional components (not shown), such as additional catalytic converters and/or particle filters, which can be arranged upstream and/or downstream of the SCR catalytic converter 201.

As noted above, a supply of an additive is needed in connection with reduction of the concentration of nitrogen oxides NO_x in the exhaust gases from the combustion engine by means of the utilization of an SCR catalytic converter. Said additive is often urea-based, and can consist, for example, of AdBlue, which consists in principle of urea diluted with water. Urea forms ammonia when heated. Alternatively, another suitable additive can be used.

Fig. 2 shows, in addition to said catalytic converter 201, a urea tank 202 that is connected to a urea dosing system (UDS) 203.

The urea dosing system 203 comprises or is controlled by a UDS control unit 204, which generates control signals for controlling the supply of additive so that the desired amount is injected into the exhaust gas stream 119 resulting from the combustion in the cylinders of the combustion engine 101 from the tank 202 by means of an injection nozzle 205 upstream of the catalytic converter 201.

Urea dosing systems are generally well described in the prior art, and the precise manner in which the injection of additive occurs is consequently not described in detail here, but rather the present invention concerns a method for adapting the supply of additive with a view to ensuring that the supplied amount of additive corresponds to an anticipated amount of additive and, in particular, the present invention concerns a method that better utilizes the available adaptation time. One exemplary embodiment 500 according to the present invention is shown in Fig. 5 and described below, wherein the method according to the invention can be arranged so as to be performed by any suitable control unit.

Control systems in vehicles generally consist of a communication bus system consisting of one or more communication buses for connecting together a number of electronic control units (ECUs), or controllers, and various components arranged in the vehicle 100. Such a control system can thus comprise a large number of control units, and the responsibility for a specific function can be shared by more than one control unit.

For the sake of simplicity, only three electronic control units 115, 116, 131 will be shown in addition to the control unit 204 shown in Fig. 1A. The method according to the present invention can thus be arranged so as to be performed by any suitable control unit present in the control systems of the vehicle 100, such as the UDS control unit 204 or the control unit

131, which is generally responsible for the function of the post-treatment system 130, or be shared among a plurality of control units present in the vehicle 100.

Control units of the type shown are normally arranged so as to receive sensor signals from various parts of the vehicle, e.g. from the transmission, engine, clutch and/or other control units or components in the vehicle. The control unit-generated control signals are normally dependent on both signals from other control units and signals from components. For example, the control by the control unit 204 of the supply of additive to the exhaust gas stream 119 will, for example, depend on information that is, for example, received from one or more additional control units. For example, the control can be based at least in part on information from the control unit 115 that is responsible for the function of the combustion engine 101.

The control units can further be arranged so as to transmit control signals to various parts and components in the vehicle, such as elements for controlling the injection nozzle 205. The present invention can thus be implemented in any arbitrary one of the foregoing control units, or in any other suitable control unit in the control system of the vehicle.

The control of various functions by the control units is further often controlled by programmed instructions. Said programmed instructions typically consist of a computer program, which, when executed in the control unit, causes the control unit to perform the desired control, such as controlling the various functions present in the vehicle, and to perform method steps according to the present invention.

The computer program commonly constitutes part of a computer program product, wherein the computer program product includes a suitable storage medium 121 (see Fig. 1B) with the computer program stored on said storage medium 121. The computer program can be stored in non-volatile fashion on said storage medium. Said digital storage medium 121 can, for example, consist of any of the group consisting of: ROM (Read-Only Memory), PROM (Programmable Read-Only Memory), EPROM (Erasable PROM), Flash memory, EEPROM (Electrically Erasable PROM), a hard drive unit, etc, and be arranged in or in connection with the control unit, whereupon the computer program is executed by the control unit. The behavior of the vehicle in a specific situation can thus be adapted by changing the computer program instructions.

An exemplary control unit (the UDS control unit 204) is depicted schematically in Fig. 1B, wherein the control unit can in turn comprise a calculating unit 120, which can consist of, for example, any suitable type of processor or microcomputer, e.g. a circuit for digital signal processing (Digital Signal Processor, DSP), or a circuit with a predetermined specific function (Application Specific Integrated Circuit, ASIC). The calculating unit 120 is connected to a memory unit 121, which provides the calculating unit 120 with, for example, the stored program code and/or the stored data that the calculating unit 120 requires to be able to perform calculations, e.g. to determine whether an error code is to be activated. The calculating unit 120 is also arranged so as to store partial or complete results of calculations in the memory unit 121.

The control unit is further equipped with devices 122, 123, 124, 125 for respectively receiving and transmitting input and output signals. Said input and output signals can contain waveforms, pulses or other attributes that can be detected by the devices 122, 125 for receiving input signals as information for processing by the calculating unit 120. The devices 123, 124 for transmitting output signals are arranged so as to convert calculation results from the calculating unit 120 into output signals for transfer to other parts of the control system of the vehicle and/or the component(s) for which said signals are intended. Each and every one of the connections to the devices for respectively receiving and transmitting input and output signals can consist of one or more of a cable, a data bus, such as a CAN bus (Controller Area Network bus), a MOST bus (Media Oriented Systems Transport), or some other bus configuration; or a wireless connection.

As noted above, the SCR catalytic converter 201 is dependent for its function upon access to a suitable substance by means of which a desired reduction can be carried out, such as ammonia NH_3, which, according to the foregoing, can be supplied by supplying a suitable additive. In connection with the reduction of nitrogen oxides NO_x in the SCR catalytic converter it is important that nitrogen oxide NO_x and ammonia NH_3 be supplied in the correct proportions to one another. If too small an amount of ammonia NH_3 is supplied to the SCR catalytic converter in relation to the presence of nitrogen oxides NO_x in the exhaust gas stream, a surplus of nitrogen oxides NO_x will prevail after the SCR catalytic converter 201. Nitrogen oxide emissions are, as noted, regulated under laws that include the limit values that may not be exceeded. Too small an amount of ammonia NH_3 thus entails a risk that nitrogen oxides

NO_x will not be reduced to the desired extent, whereupon the limit values with respect to nitrogen oxides NO_x may be exceeded.

Conversely, if too large an amount of ammonia NH_3 is supplied in relation to the amount of nitrogen oxides NO_x in the exhaust gas stream, a surplus of ammonia will prevail after the SCR catalytic converter, and will thus be released into the surroundings of the vehicle 100. Ammonia NH_3 consists of a strong smelling and also harmful substance that is also often regulated under laws regarding emissions, with the result that an ammonia surplus is not desirable either.

It is thus desirable for the supply of ammonia NH_3 to be regulated in such a way that as little nitrogen oxide NO_x and/or ammonia NH_3 as possible is present when the exhaust gas stream is released into the surroundings of the vehicle 100. For this reason, adaptations of the supply of additive are carried out in order to ensure that an anticipated amount of additive is actually supplied to the exhaust gas stream.

In connection with such adaptation, as well as for the general determination of the presence of nitrogen oxides in the exhaust gas stream downstream of the SCR catalytic converter, an NO_x sensor 208 (see Fig. 2) arranged downstream of the SCR catalytic converter 201 can be used. The NO_x sensor 208 is, however, commonly cross-sensitive to ammonia NH_3, which means that emitted sensor signals represent the combined presence of nitrogen oxides NO_x and ammonia NH_3. This means that, in those cases in which the NO_x sensor 208 indicates an elevated level, it is not possible to determine, based solely on the emitted signals, whether the reason why the level is elevated is that the dosage of ammonia is too high, whereupon the share of ammonia downstream of the SCR catalytic converter is consequently too high, or whether the dosage of ammonia is too low and the proportion of residual nitrogen oxides NO_x downstream of the SCR catalytic converter 201 is thus far too high.

In order to avoid such uncertainty, a method is commonly applied in connection with such adaptation wherein the NO_x conversion is reduced, i.e. the supply of additive is decreased to a level at which it can be ensured that complete NO_x conversion will not prevail, and that a surplus of nitrogen oxides NO_x in the exhaust gas stream is consequently certain to prevail.

This is illustrated in Fig. 3, where a curve 305 representing the NO_x conversion as a function of supplied additive is shown. The x-axis represents the ammonia-nitrogen oxide ratio (ANR), which consists of $\frac{NH_3}{rawNO_x}$, i.e. the amount (content) of ammonia NH_3 divided by ”$rawNO_x$”.

”$rawNO_x$” consists of the untreated amount (content) of nitrogen oxide NO_x upstream of the SCR catalytic converter 201. The amount/content of $rawNO_x$ can be determined by means of an NO_xsensor 207 arranged upstream of the SCR catalytic converter 201, and preferably upstream of the position at which additive is being supplied to said post-treatment system. One mole of ammonia NH_3 is generally needed for the reduction of one mole of nitrogen oxides NO_x, with the result that complete (100%) conversion, i.e. complete reduction of nitrogen oxides NO_x, is ideally achieved at an ANR ratio = 1, as is also shown in the figure. During the reduction, ammonia and nitrogen oxides react with one another to form mainly nitrogen gas and water vapor. The same amounts of ammonia and nitrogen oxides NO_x are thus ideally supplied to the exhaust gas stream. A deficit of ammonia thus prevails to the left if ANR=1 in Fig. 3, while a surplus of ammonia prevails to the right if ANR=1.

In Fig. 3 the y-axis represents the conversion rate as a percentage, which can be expressed, for example, in percent, as:

$$(1-\frac{tpNO_x}{rawNO_x})\cdot 100 \qquad \text{(equation 1)}$$

where $tpNO_x$ represents ”tailpipe” NO_x, i.e. the presence of nitrogen oxides when the exhaust gas stream is released into the surroundings of the vehicle, as determined by means of the NO_x sensor 208.

As can be seen in Fig. 3, one and the same estimated conversion rate can, through the use of the NO_x sensors 207, 208, be obtained for two different actual ratios, depending on the cross-sensitivity of the NO_x sensors to ammonia NH_3. This is exemplified for a conversion rate of ca. 90% by points 301 and 302 in Fig 3. The closer the conversion is to maximum (100%) conversion, the closer these points will be to one another, and if the conversion rate is high, it may be difficult to known with certainty whether the dosage is actually at point 301, whereupon an increase in the amount of supplied additive should be carried out, or if the conversion is, in practice, at point 302, with the result that the amount of supplied additive should instead be reduced.

For this reason, the conversion rate during adaptation can be reduced to a conversion rate at which it is certain, or extremely likely, that a deficit of ammonia NH_3 will prevail. This is illustrated by point 303, which in this example represents a conversion rate of ca. 80%. If, in such a situation, it is found that the anticipated conversion rate in practice is lower than (or exceeds) the anticipated conversion rate, e.g. in that the estimated conversion rate is at point 304 instead of the anticipated point 303, the supply of additive can be corrected (in this case increased) so that the anticipated conversion is achieved, in that the conversion is caused to follow curve 305 rather than 306.

By proceeding in this manner, it is thus possible to adapt the supply of additive with no, or at least with a reduced, risk that a surplus of ammonia will affect the result. However, such adaptation has the disadvantage that lowering the conversion rate unavoidably entails increased emissions of nitrogen oxides NO_x. This results in turn in it not being possible to perform the adaptation with just any frequency, because of the increased emissions, and the options in terms of adaptation may also be subject to government regulations.

As is known, vehicles are normally driven under highly variable conditions, with the result that the combustion engine works in a transient and non-stationary manner. This leads in turn to difficulties in connection with adaptation, as major variations in the estimated conversion rate will appear. Fig. 4 shows an example of how the estimated conversion can vary with the time t when the combustion engine 101 is working transiently. Line 401 represents the desired setpoint value 80% for the adaptation, the solid line 402 represents the estimated setpoint values, and the broken line 403 represents the average for the estimation, and is thus represented by point 304 in Fig. 3. Because the output of the combustion engine 101 can vary greatly during the adaptation, it can be difficult to obtain reliable values. For example, it may be desirable for the output delivered by the combustion engine 101 to reach, at least, some suitable value, whereupon only parts of the estimation shown in Fig. 4 can be considered to be representative, and thus suitable for actual use during the adaptation. This entails that the adaptation can take a very long time, e.g. in cases where longer periods of low combustion-engine load occur during the adaptation and are thus not factored in.

The present invention provides a method that better utilizes the available adaptation time, and, as noted above, Fig. 5 shows an exemplary embodiment 500 according to the present invention. The method begins in step 501, where it is determined whether adaptation is to be carried out. When this is the case, the method transitions to step 502. The adaptation can be arranged, for example, so as to be carried out at an appropriate interval, or when the NO_x sensor 208 emits values that indicate that adaptation should be carried out, or for another appropriate reason.

In step 502 the conversion rate is reduced to a first conversion rate OMV1, which can consist of any suitable conversion rate, such as 80% according to the foregoing example, or some other suitable conversion rate. The method then continues to step 503, where it is determined whether a switch to said first conversion rate OMV1 has been carried out. A degree of inertia generally prevails in the system, e.g. due to ammonia NH_3 stored in the SCR catalytic converter 201. It may consequently take a certain amount of time before the stored/built-up ammonia NH_3 has been consumed and the conversion rate has thus actually been reduced. Said reduction can be assumed to a take a certain amount of time, but, according to the present embodiment, a determination is instead made as to whether an amount of work W2 has been performed by the combustion engine 101 since the reduction of the conversion rate to said first reduction rate was requested. For example said amount of work can consist of an amount of work that is expected to reduce the built-up ammonia NH_3 to the desired extent.

This is illustrated in Figure 6, where the adaptation process according to the present example is depicted. Up until time T_1 the vehicle 100 is driven at some suitable anticipated conversion rate, such as 95%. In connection with adaptation, a lowering of the setpoint value for the nitrogen oxide conversion to OMV1 (such as to 80%) is then initiated at time T_1. Starting as of time T_1, a "settling time" is thus applied so that, e.g. ammonia built-up in the SCR catalytic converter 201 will be reduced to the desired extent, and wherein said settling time thus consists, according to one embodiment, of an amount of work performed by the combustion engine 101. The actual time that the settling process takes, i.e. the time from time T_2 in Fig. 6, can thus vary from one time to another depending upon the prevailing load on the combustion engine 101, and thus the amount of nitrogen oxides generated per unit of time.

In step 503 a determination is made as to whether a desired amount of work W2 has been performed by the combustion engine 101, and as long as such is not the case, the method remains in step 503, while the method will continue to step 504 once the desired amount of work W2 has been performed at time T_2 in Fig. 6. Said amount of work W2 can be estimated in any arbitrary suitable way, and the control system of the vehicle 100 usually contains efficient functions for estimating the work that is performed by the combustion engine 101. The work can, for example, be represented as an amount of work expressed in kilowatt hours (kWh) or another suitable unit, or alternatively represented as, for example, an amount of fuel supplied to the combustion engine 101, such as, for example, a given volume and/or weight, or a calculated energy content for the supplied fuel. According to one embodiment, a settling time is instead used that consists of some suitable amount of time that thus need not be controlled by the work performed by the combustion engine.

In step 504 the actual adaptation is initiated, and it is performed during time T_2-T_3 in Fig. 6 by setting a first variable N_1 and a second variable N_2 to zero, wherein said variables N_1 and N_2 respectively represent cumulative nitrogen oxide amounts after and before the SCR catalytic converter 201, i.e. $tpNO_{x,ack}$ and $rawNO_{x,ack}$. A variable representing the generated combustion engine work can similarly be set to zero. The NO_x sensors 207, 208 indicate an NO_x content present in the exhaust gas stream, and the actual amount of nitrogen oxide NO_x can be determined by using said NO_x content together with the exhaust gas stream flow, which can be determined in an appropriate manner, such as by means of a flow meter. Said amounts of nitrogen oxide N_1 and N_2 accumulate continuously as long as an amount of work W1 is being determined in step 505, which work can, for example, consist of an ever-greater amount of work compared to the amount of work W2 not yet performed by the combustion engine 101 of the vehicle 100 since the accumulation of nitrogen oxides NO_x was initiated. The amounts of nitrogen oxides NO_x before and after the SCR catalytic converter 201 will be accumulated as long as the desired amount of work W1 since the accumulation was initiated has not been completed.

Once the desired amount of work W1 during ongoing accumulation has been completed, the accumulation of nitrogen oxide is discontinued, and the method continues on to step 506, where the NO_x conversion is estimated, which can be performed, for example, using Equation 1 above, or through the use of a corresponding equation. For example, the conversion rate can be written as (not expressed in percent in this example):

$$(1-\frac{tpNO_{x,ack}}{rawNO_{x,ack}})=(1-\frac{N1}{N2}) \qquad \text{(Equation 2)}$$

In step 507 a determination is then made as to whether a correction of the supply of additive is to be carried out and, if this is not the case, e.g. because the estimated conversion rate corresponds to the desired conversion rate, the method ends in step 509, while the supply of additive will otherwise be corrected in step 508 before the method ends in step 509. This correction can, for example, be determined as a correction factor, which can be written, for example, as $\frac{OMV_{b\ddot{o}r}}{OMV_{est}}$, i.e. the setpoint value for the conversion rate divided by the estimated conversion rate for the adaptation. Once the accumulation of nitrogen oxide NO_x has been concluded at time T3 in Fig. 6, the setpoint value for the reduction of nitrogen oxides NO_x can be reset, e.g. in any suitable one of steps 506-509, to the prevailing setpoint value prior to the adaptation, or to another suitable setpoint value.

The present invention has the advantage that the adaptation can occur continuously and, by performing the estimation for a given amount of work, the adaptation can occur continuously regardless of whether the combustion engine 101 is delivering high or low power at the time. The time that the adaptation takes, i.e. the time between times T2-T3 in Fig. 6, will thus vary from one instance to another, whereupon the adaptation under a low combustion engine load will take a longer time, as it will take a longer time before the desired amount of nitrogen oxides has been accumulated.

During the adaptation, the estimated conversion rate will vary, e.g. according to curve 601 in 601 in Fig. 6 and, as shown, the estimation of the conversion rate will not constantly lie at the desired, e.g. 80%, but may vary markedly for various points in time. However, according to the present invention, an accurate mean value is obtained, since the work performed by the combustion engine is factored into the calculation. Conversely, according to the prior art there is a risk that, for example, measurements at points such as e.g. 602 or 603 in Fig. 6 will have a major impact on the estimate conversion ratio, with a heavy risk that an erroneous conversion rate will be determined, and consequently that an erroneous correction of the supply of additive will be carried out, since the work done by the combustion engine can vary greatly, with the result that, for example, the conversion rate under low load will have an unjustifiably heavy impact. This is avoided according to the present invention.

The present invention thus provides a method that enables a good adaptation of the supply of additive, whereby a desired conversion of nitrogen oxides NO_x can more likely be obtained.

The invention thus provides significantly improved adaptation precision compared with prior art solutions. According to the present invention, a method is also obtained wherein the available adaptation time is utilized optimally, as the entire time is utilized and the adaptation can be discontinued as soon as the desired work has been performed.

The present invention has been described above in connection with the reduction of nitrogen oxide NO_x, but, as one skilled in the art will realize, the invention is equally applicable to the reduction of any arbitrary substance wherein conversion occurs through the use of a supplied additive. The supply of additive generally follows some suitable curve, wherein said curve can be measured in engine test cells using extremely accurate sensors, and wherein the amount of supplied additive is controlled based, for example, on the amount of nitrogen oxides NO_x indicated by the NO_x sensor arranged upstream of the SCR catalytic converter. The present invention thus provides a compensation factor for compensating for deviations from said curve.

Furthermore, the setpoint value as per the method according to the invention can be arranged so as to be varied during ongoing adaptation. The reason for this can be, for example, that the capacity of the SCR catalytic converter to convert nitrogen oxide NO_x can vary under different conditions. For example, a low catalytic converter temperature entails that a smaller amount of nitrogen oxides NO_x can be reduced, while, conversely, a high catalytic converter temperature entails that a greater amount of nitrogen oxides NO_x can be reduced. The magnitude of the exhaust gas stream flow also affects the size of the catalytic converter as experienced by the exhaust gas stream.

An accumulation of nitrogen oxides NO_x upstream of the catalytic converter is used above in calculating the conversion factor. According to one embodiment, this accumulation can be replaced with a calculated amount, wherein said amount can be calculated based on any suitable model for the combustion engine and, e.g. the amount of fuel being supplied to the combustion engine. According to this embodiment, the NO_x sensor 207 shown in Fig. 2 is thus not necessary.

The present invention has been exemplified above in connection with vehicles. However, the invention is also applicable to any arbitrary means of transport, such as aircraft or watercraft, and to industrial installations in which a control system is used to control the functions that are present, and wherein parameters pertaining to the physical conditions for a unit that is being controlled by the control system can be determined.

Additional embodiments of the method and the system according to the invention are found in the accompanying claims. It is also to be noted that the system can be modified according to various embodiments of the method according to the invention (and vice versa), and that the present invention is thus in no way limited to the aforedescribed embodiments of the method according to the invention, but rather relates to and comprises any and all embodiments within the scope of the accompanying independent claims.

For example, the present invention is applicable to the adaptation of all currently known and future additives supplied to the exhaust gas stream to reduce any substance present in the exhaust gas stream. The invention according to the above is equally applicable regardless of what substance in the exhaust gas stream is being reduced. The invention is thus in no way limited to the reduction of nitrogen oxides, or to additives from which ammonia is formed.

Claims

1. A method for correcting a supply of a first additive for treating an exhaust gas stream resulting from combustion in a combustion engine (101), wherein said first additive is supplied to said exhaust gas stream, and wherein said first additive is utilized to reduce at least a first substance (NO_x), **characterized in that** the method comprises, in connection with said correction:
- initiation of a first accumulation (N1) of a representation of said first substance (NO_x), wherein said first accumulation (N1) of said representation of said first substance (NO_x) represents an accumulated amount of said first substance (NO_x) downstream of said supply of said first additive;
- determination as to whether a first amount of work (W1) has been performed by said combustion engine (101) during the accumulation of said first substance (NO_x);
- discontinuation of said first accumulation of said first substance (NO_x) when said first amount of work (W1) has been performed by said combustion engine (101); and
- correction of the supply of said first additive based on said first accumulation (N1) of said first substance (NO_x).

2. A method according to claim 1, further comprising:
- utilization of signals emitted by a first sensor arranged downstream of said supply of said first additive during said first accumulation (N1) of said first substance (NO_x).

3. A method according to claim 1 or 2, wherein said first accumulation (N1) of said first substance (NO_x) is an accumulation of the amount of said first substance (NO_x) that is passing with said exhaust gas stream.

4. A method according to any of claims 1-3, further comprising:
- comparison of said first accumulation (N1) of said first substance (NO_x) with a second amount (N2), and
- correction of the supply of said first additive based on said comparison.

5. A method according to claim 4, wherein said second amount (N2) represents a second accumulation of said first substance (NO_x) in said exhaust gas stream upstream of said supply of said first additive.

6. A method according to claim 4 or 5, wherein said second amount (N2) is determined through the use of a sensor (207) provided upstream of said supply of said first additive.

7. A method according to any of claims 4-6, further comprising:
- determination of a ratio between said first amount (N1) and said second amount (N2),
- comparison of said determined ratio with a first ratio, and
- correction of the supply of said first additive based on said comparison.

8. A method according to any of the preceding claims, further comprising, before said first accumulation of said first substance (NO_x) is initiated:
– reduction of the supply of said first additive to said exhaust gas stream.

9. A method according to claim 8, further comprising a reduction of said supply of said first additive to a first conversion rate with respect to the reduction of said first substance (NO_x).

10. A method according to claim 8 or 9, further comprising:
- reduction of the supply of additive to a first amount, wherein said first amount consists of an amount corresponding to a reduction at which a smaller amount of additive is supplied than is necessary for a complete reduction of said first substance.

11. A method according to claim 10, wherein said first amount consists of an amount at which the anticipated conversion rate for the reduction of said first substance maximally equals any of the conversion rates comprising: 90% of complete reduction, 80% of complete reduction, 50% of complete reduction.

12. A method according to any of claims 8-11, further comprising:
- discontinuation of said reduction of said supply of said first additive when said supply of said first additive has been corrected.

13. A method according to any of claims 8-12, further comprising:
- initiation of said first accumulation (N1) of said first substance (NO_x) a first time (T2-T1) after said supply of said first additive has been reduced.

14. A method according to any of claims 8-13, further comprising:
- determination as to whether a second amount of work (W2) has been performed by

said combustion engine (101) since the reduction of said supply of said first additive was initiated, and

- initiation of said first accumulation (N1) of said first substance (NO_x) when said second amount of work (W2) has been performed by said combustion engine (101).

15. A method according to claim 1 or 14, wherein said first and/or second amount of work consists of an amount of work corresponding to a first number of kilowatt hours (kWh) or a first amount of fuel supplied to said combustion engine (101).

16. A method according to any of the preceding claims, further comprising determination of a correction factor for correcting the supply of said first additive.

17. A method according to any of the preceding claims, wherein said first additive is supplied upstream of a first catalytic converter (201), and wherein said first accumulation (N1) of said first substance (NO_x) consists of an accumulation of a representation of said first substance (NO_x) downstream of said first catalytic converter (201).

18. A method according to claim 17, wherein said first catalytic converter consists of an SCR catalytic converter (201).

19. A method according to any of the preceding claims, wherein said first accumulation (N1) of a representation of said first substance (NO_x) is carried out independent of the power output by said combustion engine (101).

20. A method according to any of the preceding claims, wherein said first accumulation (N1) of a representation of said first substance (NO_x) is carried out continuously independent of the power output by said combustion engine (101).

21. A computer program containing program code, which, when said program code is executed in a computer, causes said computer to perform the method according to any of claims 1-20.

22. A computer program product containing a computer-readable medium and a computer program according to claim 21, wherein said computer program is contained in said computer-readable medium.

23. A system for correcting the supply of a first additive for treating an exhaust gas stream resulting from combustion in a combustion engine (101), wherein said first

additive is supplied to said exhaust gas stream, and wherein said first additive is used to reduce at least a first substance (NO_x) present in said exhaust gas stream, **characterized in that** the system comprises elements adapted , in connection with said correction, to:

- initiate a first accumulation (N1) of a representation of said first substance (NO_x), wherein said first accumulation (N1) of a representation of said first substance (NO_x) represents an accumulated amount of said first substance (NO_x) downstream of said supply of said first additive;
- determine whether a first amount of work (W1) has been performed by said combustion engine (101) during the accumulation of said first substance (NO_x);
- discontinue said first accumulation of said first substance (NO_x) when said first amount of work (W1) has been performed by said combustion engine (101); and
- correct the supply of said first additive based on said first accumulation (N1) of said first substance (NO_x).

24. A vehicle (100), **characterized in that** it comprises a system according to claim 23.

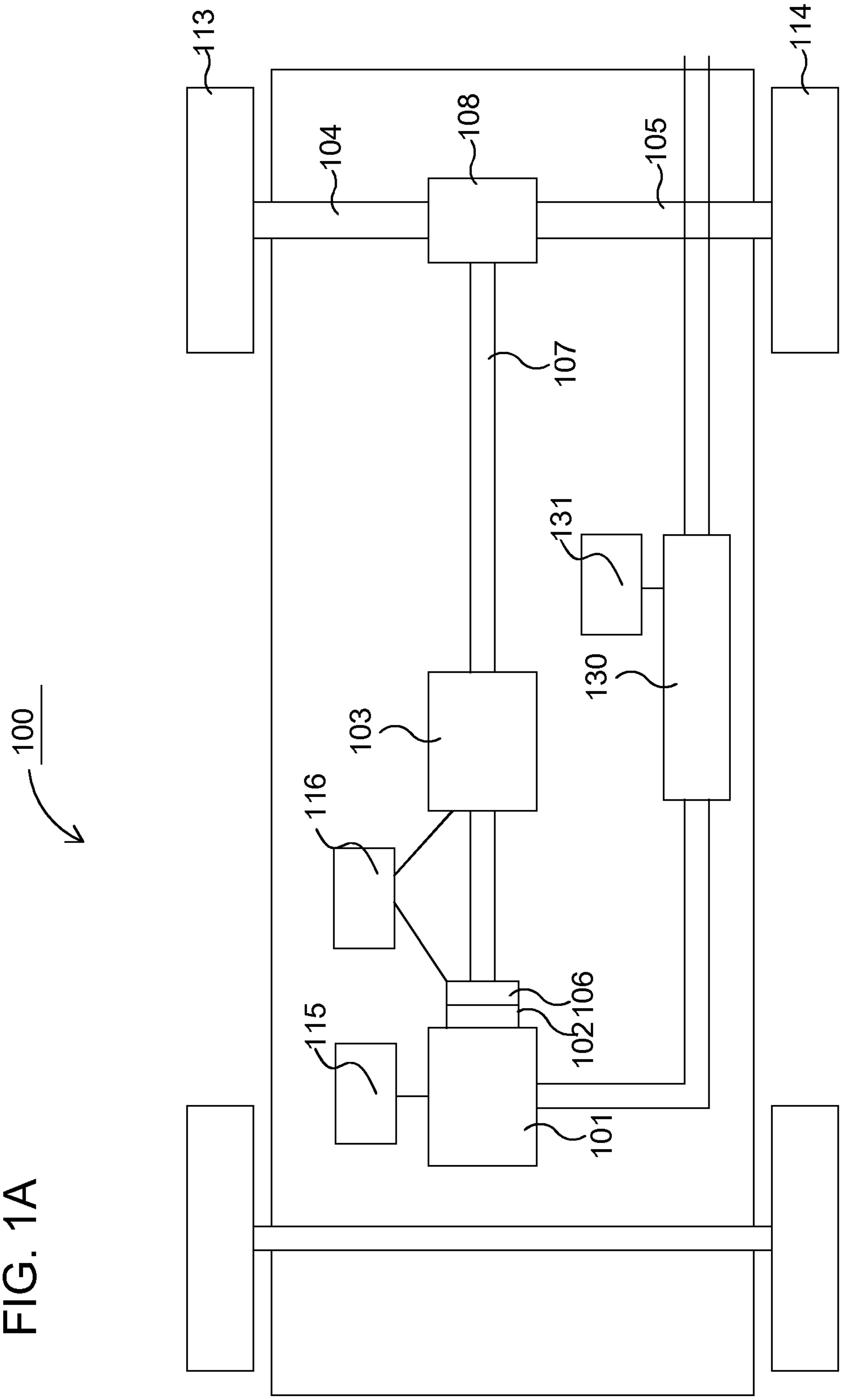


FIG. 1A

FIG. 1B

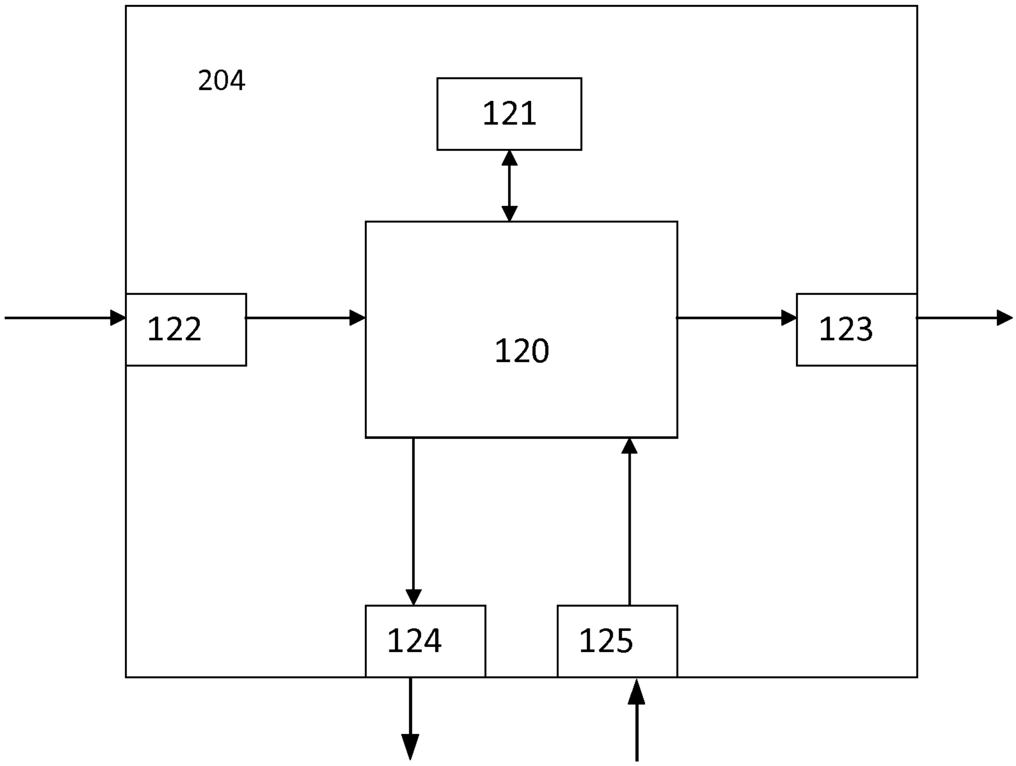
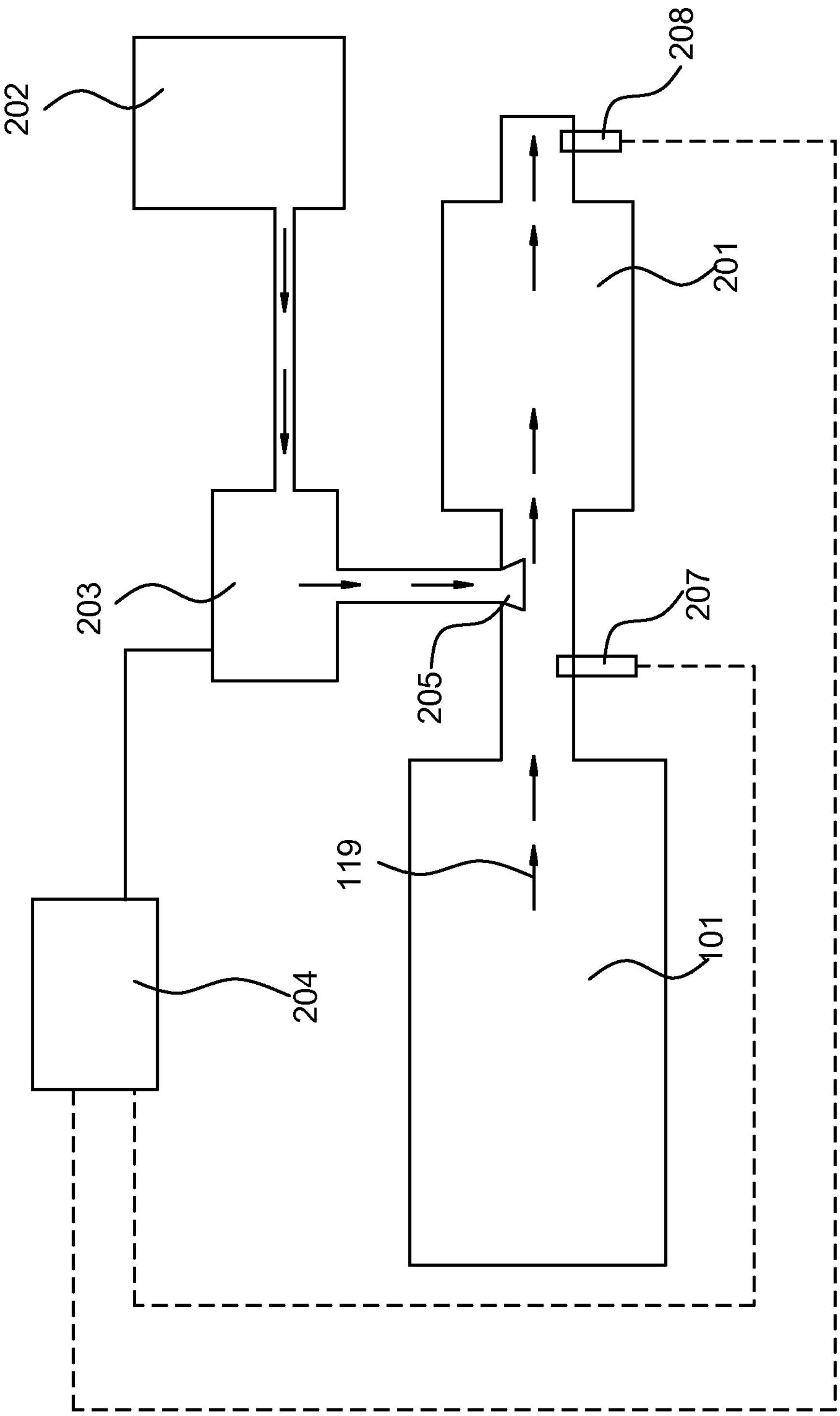


Fig. 2



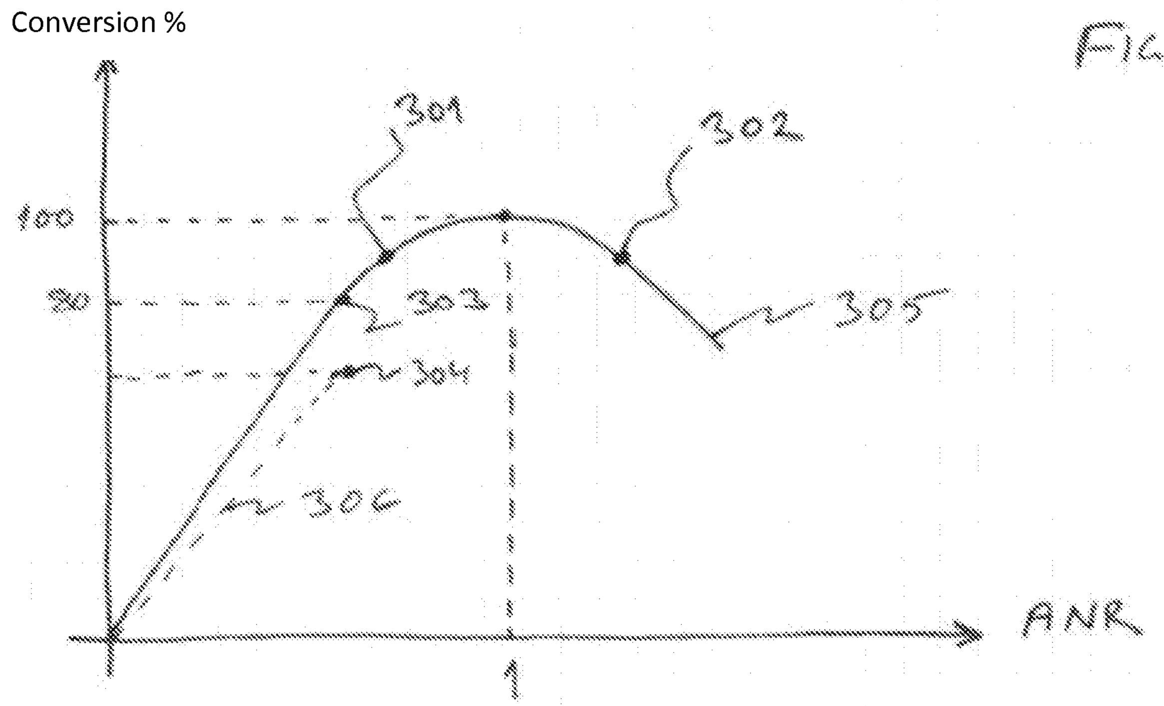

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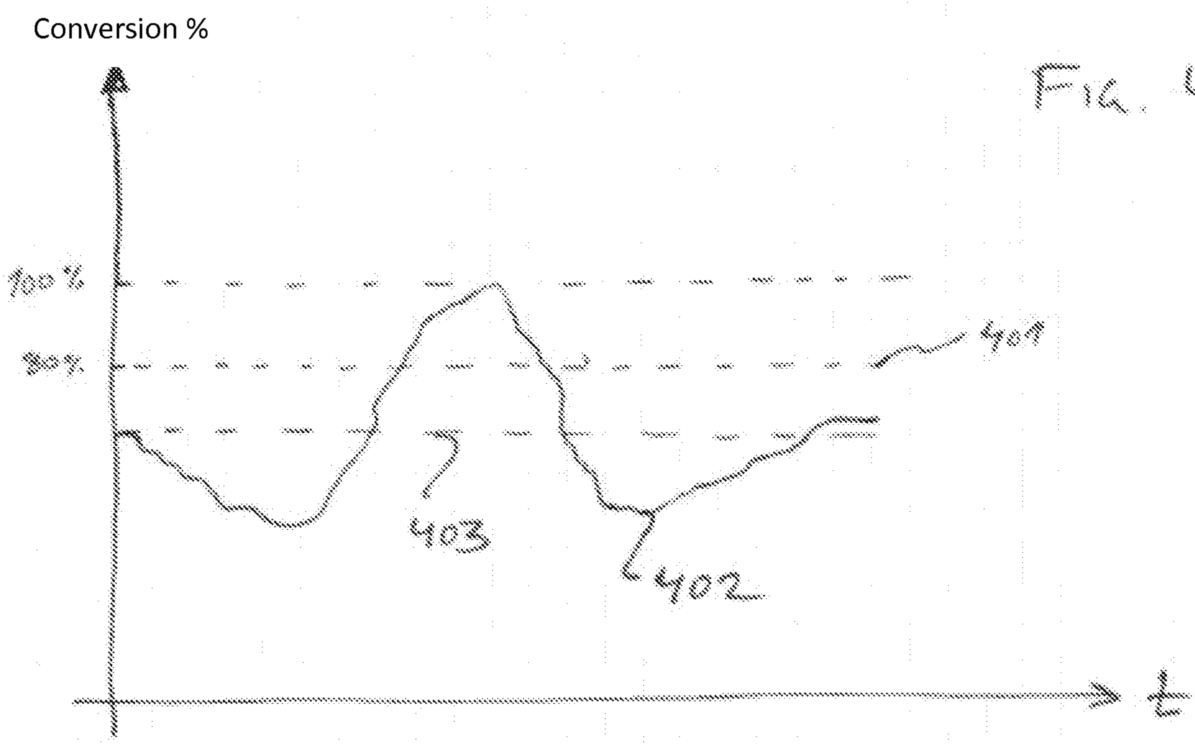
Fig. 3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402
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Fig. 4

Fig. 5

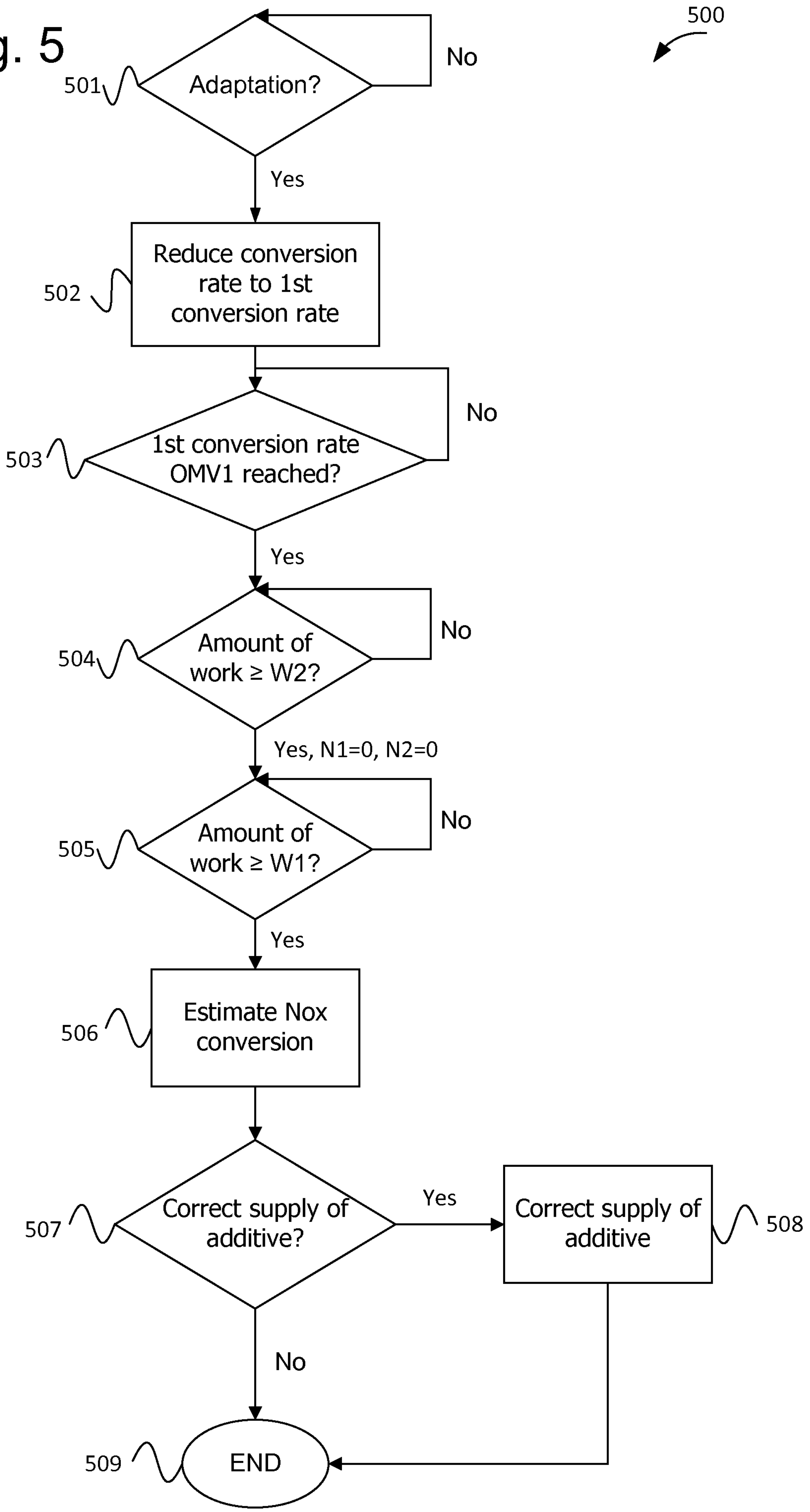
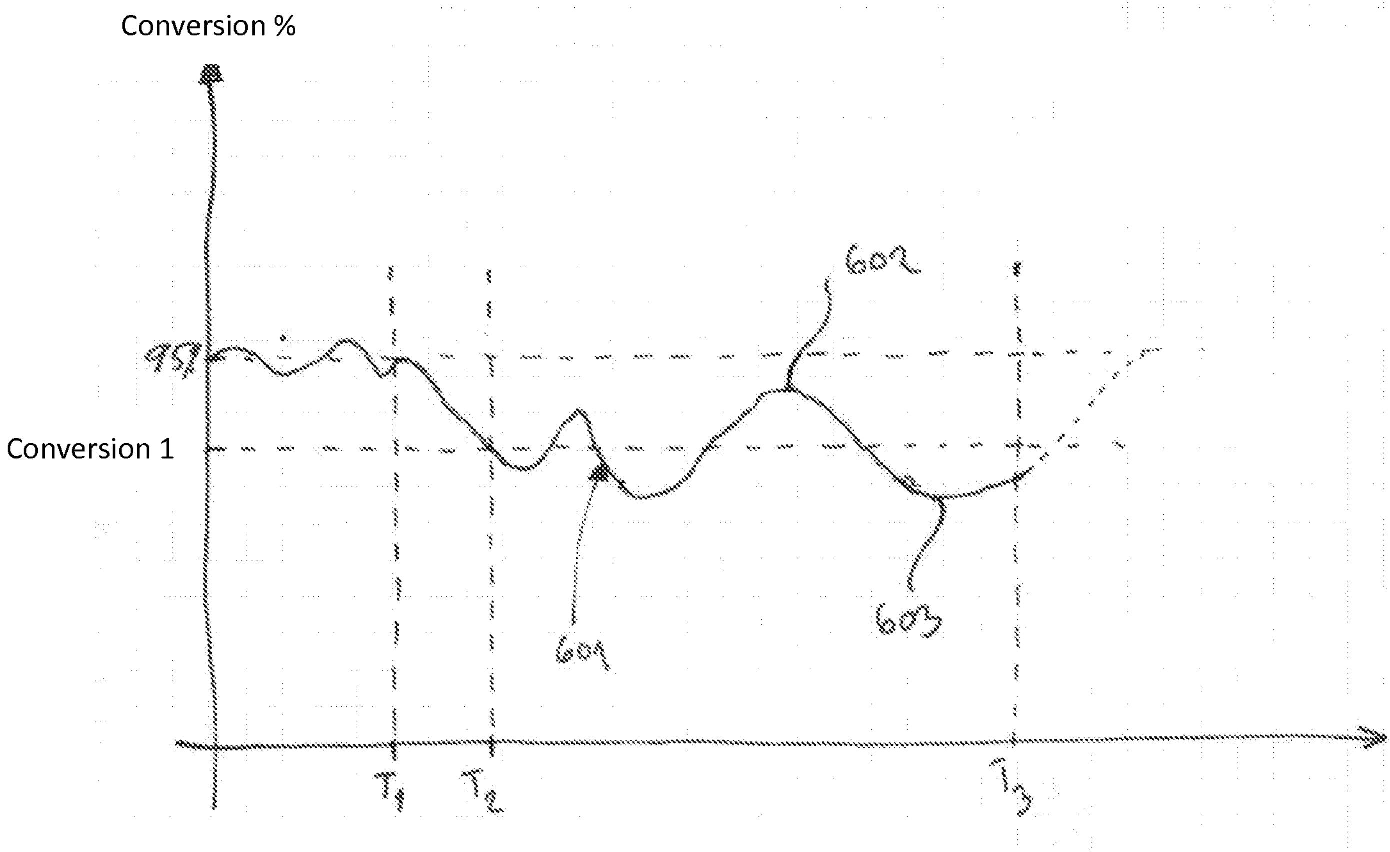

500
501
Adaptation?
No
Yes
502
Reduce conversion rate to 1st conversion rate
503
1st conversion rate OMV1 reached?
No
Yes
504
Amount of work ≥ W2?
No
Yes, N1=0, N2=0
505
Amount of work ≥ W1?
No
Yes
506
Estimate Nox conversion
507
Correct supply of additive?
Yes
508
Correct supply of additive
No
509
END

Fig. 6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2015/050090

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 20100223914 A1 (DOERING ANDREAS ET AL), 9 September 2010 (2010-09-09); paragraphs [0028]-[0046]	1-7, 15-24
Y		8-14
	--	
Y	DE 102008040377 A1 (BOSCH GMBH ROBERT), 14 January 2010 (2010-01-14); paragraphs [0012]-[0015], [0026], [0027], [0049]-[0059]; figures 3-5	8-14
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☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30-04-2015	04-05-2015
Name and mailing address of the ISA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Facsimile No. + 46 8 666 02 86	Authorized officer Niels Rasmussen Telephone No. + 46 8 782 25 00

International application No.
PCT/SE2015/050090

Continuation of: second sheet

International Patent Classification (IPC)

F01N 9/00 (2006.01)
F01N 3/20 (2006.01)

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