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(56) Documents Cited:
CN 205297692 U **US 20150377111 A1**
US 20150167517 A1 **US 20130145822 A1**
US 20110232364 A1

(58) Field of Search:
INT CL **F01N**
Other: **EPODOC, WPI**

(54) Title of the Invention: **Exhaust backpressure detection**
Abstract Title: **Method of controlling operation of an after-treatment apparatus for an internal combustion engine**

(57) Disclosed is a method of controlling operation of an after-treatment apparatus for an internal combustion engine. The after-treatment apparatus comprises a Diesel Particulate Filter (DPF), a Selective Catalytic Reduction (SCR) module downstream of the DPF and an injector for injecting reductant upstream of the SCR module. The after-treatment apparatus also comprises a first pressure sensor upstream of the DPF and configured to output a first pressure value representative of pressure of gas entering the DPF and a second pressure sensor configured to output a pressure value representative of a pressure difference over the DPF. A controller is configured to calculate an inferred pressure value indicative of a pressure downstream of the DPF based on the pressure of the gas entering the DPF and the pressure difference across the DPF. The method comprises comparing the inferred value of pressure downstream of the DPF with a reference pressure value when a mass flow through the DPF exceeds a mass flow rate threshold value. The reference pressure is dependent upon the mass flow through the DPF. The difference between the inferred downstream pressure and the reference pressure and a selective catalytic reduction module regeneration or maintenance indicator is triggered based on the result. An after-treatment system and computer program for carrying out the method are also disclosed.

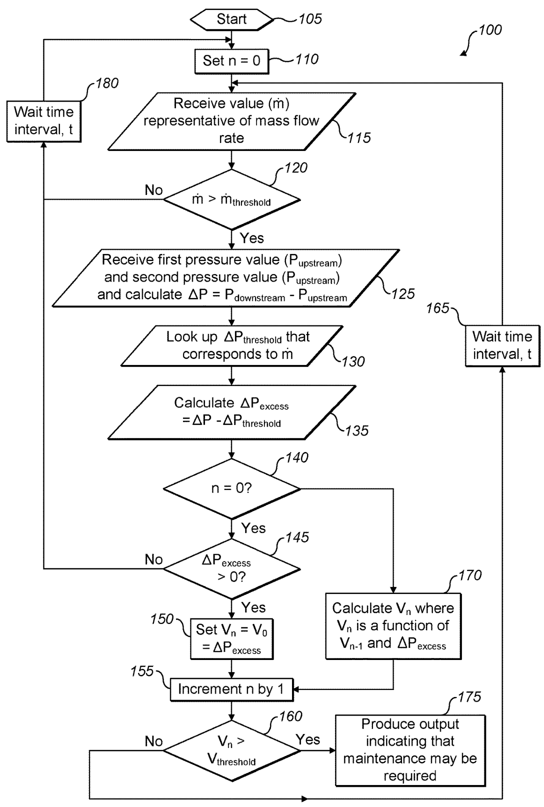

FIG. 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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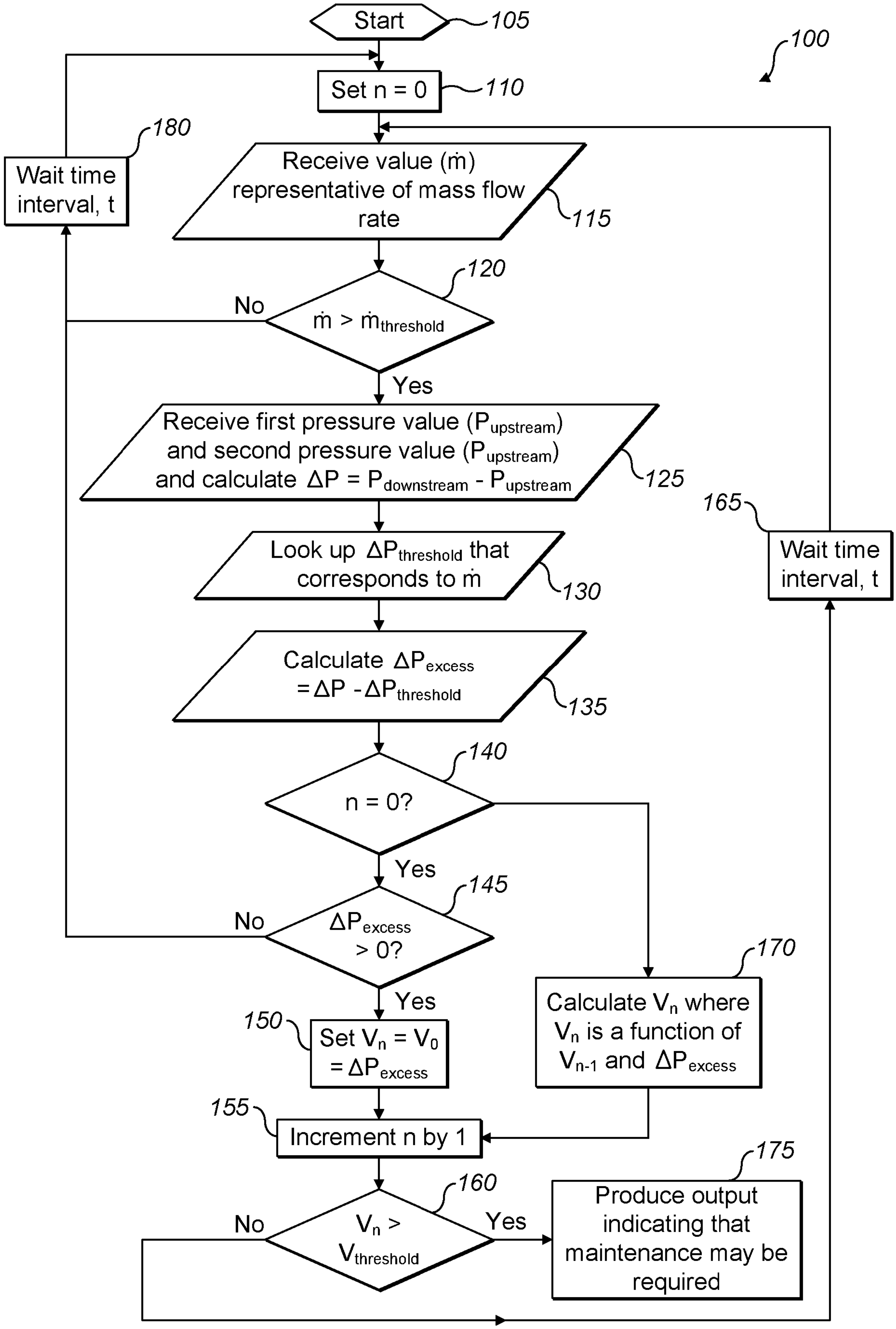
Start
105
100
Set n = 0
110
Receive value ($\dot{m}$) representative of mass flow rate
115
$\dot{m} > \dot{m}_{threshold}$
120
No
Yes
Wait time interval, t
180
Receive first pressure value ($P_{upstream}$) and second pressure value ($P_{upstream}$) and calculate $\Delta P = P_{downstream} - P_{upstream}$
125
Look up $\Delta P_{threshold}$ that corresponds to $\dot{m}$
130
Calculate $\Delta P_{excess} = \Delta P - \Delta P_{threshold}$
135
n = 0?
140
Yes
$\Delta P_{excess} > 0$?
145
No
Yes
Set $V_n = V_0 = \Delta P_{excess}$
150
Calculate V_n where V_n is a function of V_{n-1} and ΔP_{excess}
170
Increment n by 1
155
$V_n > V_{threshold}$
160
No
Yes
Produce output indicating that maintenance may be required
175
Wait time interval, t
165

FIG. 1

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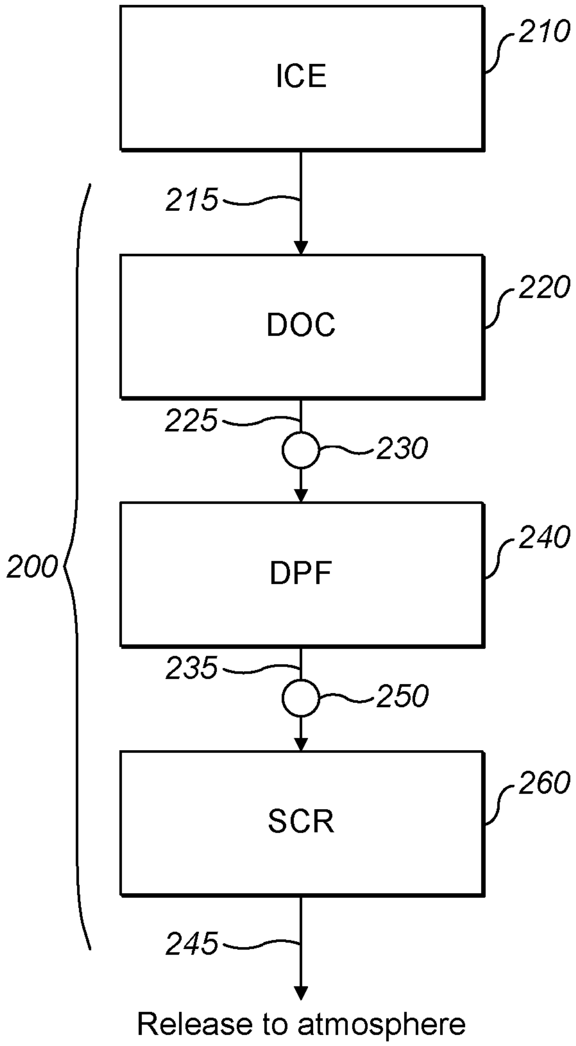
ICE
210
215
DOC
220
225
230
DPF
240
200
235
250
SCR
260
245
Release to atmosphere

FIG. 2

Exhaust Backpressure Detection

Technical Field

The disclosure relates to an apparatus for treating exhaust emitted during operation of an internal combustion engine (ICE).

Background

In order to reduce emissions released to atmosphere, it is increasingly common to employ an after-treatment system downstream of an internal combustion engine. The additional hardware and control requirements of an after-treatment system tend to increase costs. There is a need to increase the effectiveness of engine after-treatment systems whilst minimising cost.

Commonly, engine after-treatment systems may include a diesel particulate filter (DPF) for filtering particulates that may be present in the exhaust gas from being output to atmosphere. Increased exhaust pressure caused by a build-up of particulates in the DPF may negatively influence performance not only of the after-treatment system but also of the internal combustion engine to which the after-treatment system is attached. Particulates (soot) collected in the DPF must at some stage be removed to maintain the efficiency of the DPF. Methods by which particulates may be removed from the DPF are well known in the art and may generally be referred to as regeneration which occurs at elevated temperatures.

Engine after-treatment systems may also include a selective catalytic reduction (SCR) module for the purpose of reducing or eliminating mono-nitrogen oxides (NO_x) in diesel combustion emissions by conversion to diatomic nitrogen (N_2) and water (H_2O) by catalytic reaction with chemicals such as ammonia (NH_3) entrained in the exhaust gas. Generally ammonia is not present in exhaust gas and must therefore be introduced upstream of a catalyst, typically by injecting a urea solution into the exhaust gas which decomposes into ammonia at sufficiently high temperatures.

It is known that urea injected into an after-treatment device upstream of an SCR catalyst may solidify and form deposits downstream of the DPF and upstream of the SCR. This can cause a system restriction and, in extreme cases, the after-treatment system may become blocked. Increased exhaust pressure caused by a build-up of deposits may negatively influence performance not only of the after-treatment system but also of the internal combustion engine to which the after-treatment system is attached.

In order to control an engine after-treatment system having a DPF and an SCR effectively, it is helpful to obtain information regarding the exhaust gas being treated in the after-treatment system. By monitoring performance of the after-treatment system, it may be possible to identify when maintenance procedures should be implemented, for example for the purpose of removing particulates from the DPF or removing urea deposits upstream of the SCR.

It is known to use an RF (radio frequency) soot sensor to detect and measure particulate deposits in the DPF. An RF soot sensor commonly comprises a pair of antennae, one at each end of the DPF, and equates changes in RF behaviour to changes in particulate build-up in the DPF. An RF soot sensor having an antenna at each end of the DPF is unable to provide information regarding urea deposits that may be downstream of the downstream antenna.

Against this background, there is provided an after-treatment system having monitoring functionality that not only detects a build-up of particulates in the DPF but also detects a build-up of urea deposit downstream of the DPF.

Summary of the disclosure

Against this background there is provided a method of controlling operation of an after-treatment apparatus for an internal combustion engine, the after-treatment apparatus comprising:

a diesel particulate filter;

a selective catalytic reduction module downstream of the diesel particulate filter;

an injector for injecting reductant upstream of the selective catalytic reduction module;

a first pressure sensor upstream of the diesel particulate filter and configured to output a first pressure value, $\mathbf{P_{upstream}}$, representative of pressure of gas entering the diesel particulate filter;

a second pressure sensor configured to output a pressure value, $\mathbf{\Delta P_{DPF}}$, representative of a pressure difference between a first location and a second location wherein the first location is upstream of the diesel particulate filter and the second location is downstream of the diesel particulate filter; and

a controller configured to calculate an inferred pressure value, $\mathbf{P_{downstream}}$, indicative of a pressure downstream of the diesel particulate filter wherein $\mathbf{P_{downstream}} = \mathbf{P_{upstream}} - \mathbf{\Delta P_{DPF}}$ and configured to receive a value representative of mass flow rate, $\dot{\mathbf{m}}$, through the after-treatment apparatus;

the method comprising:

(a) in an event that $\dot{\mathbf{m}}$ exceeds a mass flow rate threshold value, $\dot{\mathbf{m}}_{\mathbf{threshold}}$, comparing the value of $\mathbf{P_{downstream}}$ with a reference pressure value, $\mathbf{P_{reference}}$, wherein $\mathbf{P_{reference}}$ is dependent upon the value of $\dot{\mathbf{m}}$, and calculating a value for $\mathbf{P_{gap}}$, wherein $\mathbf{P_{gap}} = \mathbf{P_{downstream}} - \mathbf{P_{reference}}$;

(b) based on the value of $\mathbf{P_{gap}}$, selectively triggering a selective catalytic reduction module regeneration or maintenance indicator.

Brief description of the drawings

Figure 1 shows a flow chart that illustrates control methodology of an after-treatment apparatus in accordance with the present disclosure; and

Figure 2 shows a highly schematic representation of an internal combustion engine and associated after-treatment apparatus in accordance with the present disclosure.

Detailed description

Shown in Figure 2 is a highly schematic representation of an internal combustion engine 210 and associated after-treatment apparatus 200.

In the specific embodiment of Figure 2, an outlet of the internal combustion engine 210 is connected to an inlet of the after-treatment apparatus 200 via a first conduit 215.

At a downstream end of the first conduit 215 after-treatment apparatus may be located a diesel oxidation catalyst (DOC) 220. A downstream end of the diesel oxidation catalyst 220 may be connected to an upstream end of a diesel particulate filter (DPF) 240 via a second conduit 225. The second conduit 225 may comprise a first pressure sensor 230 configured to provide a value, $\mathbf{P_{upstream}}$, for the absolute pressure of gas in the second conduit 225. A downstream end of the diesel particulate filter 240 may be connected to an upstream end of a selective catalytic reduction (SCR) module 260 via a third conduit 235. A second pressure sensor 250 may be provided in order to output a value, $\mathbf{\Delta P_{DPF}}$, corresponding to pressure difference across the DPF. A first bypass conduit 249 may provide a fluid communication link between the second conduit 225 adjacent the first pressure sensor 230 and a first side of the second pressure sensor 250. A second bypass conduit 251 may provide a fluid communication link between a second side of the second pressure sensor 250 and the third conduit 235. The after-treatment system may further comprise a fourth conduit 245 at a downstream end of the SCR via which gas from the after-treatment system 200 may be released to atmosphere.

The diesel oxidation catalyst 220 as illustrated in the illustrated embodiment of Figure 2 is entirely optional and in embodiments that do not include diesel oxidation catalyst 220, the first conduit 215 may join directly to the second conduit 225.

Signals produced by the first and second pressure sensors may be used by a control system of the internal combustion engine and/or after-treatment system to determine potential build-ups in pressure within the diesel particulate filter 240 that may be caused by a build-up of particulates within the filter. This feedback may be used by the controller in determining when it may be appropriate to initiate a procedure for removing particulates. Such a procedure for removing particulates may include, for example, increasing the temperature of exhaust gas flowing through the after-treatment system 200 and potentially also releasing un-combusted fuel into the after-treatment system 200 such that the fuel burns in the DOC 220 at high temperature so as to combust particulates that may have built-up in the DPF 240 over time. Alternatively, the procedure for reducing particulates may involve use of a burner within the DPF that directly burns off accumulated soot.

A control strategy may be implemented to make use of the pressure value readings from the first and second pressure sensors 230, 250 not only regarding particulates that may have accumulated in the DPF but also to provide some insight into potential build-up of pressure at an inlet end of the SCR 260 downstream of the diesel particulate filter (240) and downstream of both pressure sensors (230, 250).

A flowchart showing a potential implementation of such a strategy is illustrated in Figure 1.

The strategy may involve receiving a value, $\dot{\mathbf{m}}$, that is representative of mass flow rate through the after-treatment system (reference 110). The mass flow rate through the after-treatment system may be derived from a calculation based on a carbon balance method using set points, and engine sensor readings on the engine.

In the event that $\dot{\mathbf{m}}$ is less than a predetermined threshold ($\dot{\mathbf{m}}_{\mathbf{threshold}}$) (see reference 115) then it may be that the strategy is not employed. Instead the controller may wait a fixed time interval, **t**, (reference 160) before determining if the latest value for $\dot{\mathbf{m}}$ is less than the predetermined threshold ($\dot{\mathbf{m}}_{\mathbf{threshold}}$).

If and when $\dot{\mathbf{m}}$ is greater than $\dot{\mathbf{m}}_{\mathbf{threshold}}$, then the strategy may be implemented.

Subsequently, $\mathbf{\Delta P_{DPF}}$ is subtracted from $\mathbf{P_{upstream}}$ in order to provide a value, $\mathbf{P_{downstream}}$, indicative of an absolute pressure upstream of the SCR (reference 120).

Next, $\mathbf{P_{downstream}}$ is compared to a reference value $\mathbf{P_{reference}}$ obtained (reference 125) from a data library and/or from a calculation routine that provides values for $\mathbf{P_{reference}}$. The value for $\mathbf{P_{reference}}$ provided by the data library and/or the calculation routine may be dependent upon:

a current value for $\dot{\mathbf{m}}$;

a current value for atmospheric pressure; plus, optionally,

a current value for temperature of exhaust gas in the after-treatment system.

A current value for atmospheric pressure may be provided by a pressure sensor 270 located on the after-treatment system or elsewhere on a machine to which the after-treatment system is attached. Alternatively, a current value for atmospheric pressure may be received from an external source such via a network, for example.

Whether determined by a data library (e.g. a look up table) or by a calculation routine or by a combination of both, the range of values for $\mathbf{P}_{\mathbf{reference}}$ may be viewed as resulting from a value for atmospheric pressure added to a value of expected pressure drop between (i) the location of the second pressure sensor (providing a value for $\mathbf{\Delta P}_{\mathbf{DPF}}$) and (ii) an outlet of the after-treatment system that vents to atmosphere and therefore by definition sits at ambient pressure for the current value of $\dot{\mathbf{m}}$ and exhaust temperature in a nominal "ideal" situation. A nominal "ideal" situation may be where there are no urea deposits in the after-treatment system or other unintended system restrictions that may arise during extended use. The nominal "ideal" situation may be measured or modelled such that data in the data library are populated accordingly and/or the calculation routine is configured accordingly.

Next (reference 130), a calculation is performed to provide a value a value, $\mathbf{P}_{\mathbf{gap}}$, wherein $\mathbf{P}_{\mathbf{gap}} = \mathbf{P}_{\mathbf{downstream}} - \mathbf{P}_{\mathbf{reference}}$. In the event that $\mathbf{P}_{\mathbf{gap}}$ is at or close to zero, it may be inferred that unintended system restrictions (such as urea deposits) are low. With operation, however, it may be that $\mathbf{P}_{\mathbf{gap}}$ increases which may be a result of unintended system restrictions.

It may be that $\mathbf{P}_{\mathbf{gap}}$ is passed to a numerical integrator, as shown in Figure 1. (Alternatively, (and not shown in Figure 1) it may be that $\mathbf{P}_{\mathbf{gap}}$ is only passed to the numerical integrator in the event that $\mathbf{P}_{\mathbf{gap}}$ is above a predetermined threshold and, if not, it may be that no action is taken and the strategy waits for a fixed time interval, **t**, before receiving the latest value for $\dot{\mathbf{m}}$ and continuing the process from reference 110.)

The numerical integrator may be configured to provide an output, $\mathbf{V}_{\mathbf{n}}$. The numerical integrator may receive a range of values for $\mathbf{P}_{\mathbf{gap}}$ over time. The numerical integrator may be configured to compare $\mathbf{V}_{\mathbf{n}}$ with a value, $\mathbf{V}_{\mathbf{threshold}}$, that may be indicative of pressure build-up over an extended period that might suggest that system restrictions (e.g. urea deposits) are sufficiently high to warrant some form of remedial action.

Various numerical integration models are anticipated as being within the scope of the present disclosure. For example, an embodiment of the disclosure may employ a CUSUM (or cumulative sum control chart) for this purpose.

At a point when $\mathbf{V}_{\mathbf{n}}$ is greater than $\mathbf{V}_{\mathbf{threshold}}$, an output is made indicating that maintenance may be required. The output may be, for example, an audio and/or visual indicator to an operator of the engine in conjunction with which the after-treatment system is operating. In a further example, the output may be transmitted to a remote location such as a fleet management database or similar.

By using numerical integration, this avoids brief periods of a high value of $\mathbf{P}_{gap}$ triggering the indicator. Instead, the numerical integration detects sustained high or rapidly increasing values of $\mathbf{P}_{gap}$.

In an alternative, the numerical integration may be replaced by alternative functionality for identification of sustained high or rapidly increasing values of $\mathbf{P}_{gap}$. For example, the indicator may be triggered when the value of $\mathbf{P}_{gap}$ is higher than a predetermined threshold more than a set number of times in a set period.

CLAIMS:

1. A method of controlling operation of an after-treatment apparatus for an internal combustion engine, the after-treatment apparatus comprising:

a diesel particulate filter;

a selective catalytic reduction module downstream of the diesel particulate filter;

an injector for injecting reductant upstream of the selective catalytic reduction module;

a first pressure sensor upstream of the diesel particulate filter and configured to output a first pressure value, $\mathbf{P_{upstream}}$, representative of pressure of gas entering the diesel particulate filter;

a second pressure sensor configured to output a pressure value, $\mathbf{\Delta P_{DPF}}$, representative of a pressure difference between a first location and a second location wherein the first location is upstream of the diesel particulate filter and the second location is downstream of the diesel particulate filter; and

a controller configured to calculate an inferred pressure value, $\mathbf{P_{downstream}}$, indicative of a pressure downstream of the diesel particulate filter wherein $\mathbf{P_{downstream}} = \mathbf{P_{upstream}} - \mathbf{\Delta P_{DPF}}$ and configured to receive a value representative of mass flow rate, $\dot{\mathbf{m}}$, through the after-treatment apparatus;

the method comprising:

(a) in an event that $\dot{\mathbf{m}}$ exceeds a mass flow rate threshold value, $\dot{\mathbf{m}}_{\mathbf{threshold}}$, comparing the value of $\mathbf{P_{downstream}}$ with a reference pressure value, $\mathbf{P_{reference}}$, wherein $\mathbf{P_{reference}}$ is dependent upon the value of $\dot{\mathbf{m}}$, and calculating a value for $\mathbf{P_{gap}}$, wherein $\mathbf{P_{gap}} = \mathbf{P_{downstream}} - \mathbf{P_{reference}}$;

(b) based on the value of $\mathbf{P_{gap}}$, selectively triggering a selective catalytic reduction module regeneration or maintenance indicator.

2. The method of claim 1 wherein (b) comprises:

(i) in an event that $\mathbf{P_{gap}}$ is positive, transferring the value of $\mathbf{P_{gap}}$ into a numerical integrator configured to output a numerical integrated value $\mathbf{V}$;

(ii) repeating method step (a) at predetermined intervals and transferring the value of $\mathbf{P_{gap}}$ at each interval into the numerical integrator to affect the value $\mathbf{V}$;

wherein triggering the indicator occurs in the event that $\mathbf{V}$ exceeds an integrator threshold value, $\mathbf{V_{threshold}}$.

3. The method of claim 1 wherein (b) comprises performing a count of a number of times in which $\mathbf{P_{gap}}$ exceeds a threshold and triggering the indicator in the event that $\mathbf{P_{gap}}$ exceeds a threshold in a predetermined period.

4. The method of any preceding claim wherein $\mathbf{P_{reference}}$ is dependent upon a temperature of gas in the after-treatment apparatus.

5. The method of any preceding claim wherein $\mathbf{P_{reference}}$ is determined by a value representative of atmospheric pressure plus an expected pressure increase attributed to elements of the after-treatment apparatus between the second location and the outlet.

6. The method of claim 2 or any claim dependent upon claim 2 wherein the value V is reset to zero in the event of a regeneration event taking place.

7. The method of any preceding claim wherein the controller is configured to compute a function of the first pressure value and the second pressure value in order to provide a result indicative of an amount of particulate matter that may be present in the diesel particulate filter.

8. The method of any preceding claim wherein the after-treatment apparatus further comprises an audio and/or visual indicator and wherein the method further comprises providing the output to the audio and/or visual indicator in order to provide feedback to an operator of the after-treatment apparatus.

9. The method of any preceding claim wherein the after-treatment apparatus further comprises a transmitter configured to transmit the output over a data network to a location outside the after-treatment apparatus.

10. An after-treatment apparatus comprising:

a diesel particulate filter;

a selective catalytic reduction module downstream of the diesel particulate filter;

an injector for injecting reductant upstream of the selective catalytic reduction module;

a first pressure sensor upstream of the diesel particulate filter and configured to output a first pressure value, $\mathbf{P_{upstream}}$, representative of pressure of gas entering the diesel particulate filter;

a second pressure sensor configured to output a pressure value, $\mathbf{\Delta P_{DPF}}$, representative of a pressure difference between a first location and a second location wherein the first location is upstream of the diesel particulate filter and the second location is downstream of the diesel particulate filter; and

a controller configured to calculate an inferred pressure value, $\mathbf{P_{downstream}}$, indicative of a pressure downstream of the diesel particulate filter wherein $\mathbf{P_{downstream}} = \mathbf{P_{upstream}} - \mathbf{\Delta P_{DPF}}$ and configured to receive a value representative of mass flow rate, $\dot{\mathbf{m}}$, through the after-treatment apparatus;

the controller being configured to:

(a) in an event that $\dot{\mathbf{m}}$ exceeds a mass flow rate threshold value, $\dot{\mathbf{m}}_{\mathbf{threshold}}$, comparing the value of $\mathbf{P_{downstream}}$ with a reference pressure value, $\mathbf{P_{reference}}$, wherein $\mathbf{P_{reference}}$ is dependent upon the value of $\dot{\mathbf{m}}$, and calculating a value for $\mathbf{P_{gap}}$, wherein $\mathbf{P_{gap}} = \mathbf{P_{downstream}} - \mathbf{P_{reference}}$;

(b) based on the value of $\mathbf{P_{gap}}$, selectively trigger a selective catalytic reduction module regeneration or maintenance indicator.

11. The after-treatment apparatus of claim 10 wherein (b) comprises:

(i) in an event that $\mathbf{P_{gap}}$ is positive, transferring the value of $\mathbf{P_{gap}}$ into a numerical integrator configured to output a numerical integrated value **V**;

(ii) repeating method step (a) at predetermined intervals and transferring the value of $\mathbf{P_{gap}}$ at each interval into the numerical integrator to affect the value **V**;

wherein triggering the indicator occurs in an event that **V** exceeds an integrator threshold value, $\mathbf{V_{threshold}}$.

12. The after-treatment apparatus of claim 10 wherein (b) comprises performing a count of a number of times in which $\mathbf{P_{gap}}$ exceeds a threshold and triggering the indicator in the event that $\mathbf{P_{gap}}$ exceeds a threshold in a predetermined period.

13. The after-treatment apparatus of any of claims 10 to 12 further comprising an audio and/or visual indicator configured to provide information to an operator of the after-treatment apparatus, wherein the output is provided to the audio and/or visual indicator so

as to provide an indication to the operator that regeneration and/or maintenance of the selective catalytic reduction apparatus may be required.

14. A machine comprising an internal combustion engine and an after-treatment apparatus in accordance with any of claims 10 to 13.

15. The machine of claim 14 wherein an engine control unit of the machine comprises the controller of the after-treatment apparatus.

16. The machine of claim 14 or claim 15 when dependent upon claim 13 wherein a dashboard of a cab of the machine comprises the audio and/or visual indicator.

17. A program for a computer comprising instructions for controlling an after-treatment system, the after-treatment system comprising:

a diesel particulate filter;

a selective catalytic reduction module downstream of the diesel particulate filter;

an injector for injecting reductant upstream of the selective catalytic reduction module;

a first pressure sensor upstream of the diesel particulate filter and configured to output a first pressure value, $\mathbf{P_{upstream}}$, representative of pressure of gas entering the diesel particulate filter; and

a second pressure sensor configured to output a pressure value, $\mathbf{\Delta P_{DPF}}$, representative of a pressure difference between a first location and a second location wherein the first location is upstream of the diesel particulate filter and the second location is downstream of the diesel particulate filter;

wherein the computer program is configured to calculate an inferred pressure value, $\mathbf{P_{downstream}}$, indicative of a pressure downstream of the diesel particulate filter wherein $\mathbf{P_{downstream}} = \mathbf{P_{upstream}} - \mathbf{\Delta P_{DPF}}$ and configured to receive a value representative of mass flow rate, $\dot{\mathbf{m}}$, through the after-treatment apparatus;

and the computer program is configured to:

(a) in an event that $\dot{\mathbf{m}}$ exceeds a mass flow rate threshold value, $\dot{\mathbf{m}}_{\mathbf{threshold}}$, compare the value of $\mathbf{P_{downstream}}$ with a reference pressure value, $\mathbf{P_{reference}}$, wherein $\mathbf{P_{reference}}$ is dependent upon the value of $\dot{\mathbf{m}}$, and calculating a value for $\mathbf{P_{gap}}$, wherein $\mathbf{P_{gap}} = \mathbf{P_{downstream}} - \mathbf{P_{reference}}$; and

(b) based on the value of $\mathbf{P}_{gap}$, to selectively triggering a selective catalytic reduction module regeneration or maintenance indicator.

Intellectual Property Office

Application No:	GB1604613.8	**Examiner:**	Mr Alastair Kelly
Claims searched:	1-17	**Date of search:**	30 September 2016

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	US2013/145822 A1 [KARLSSON] See abstract and figures
A	-	US2015/377111 A1 [LAURELL] See abstract and figures
A	-	US2011/232364 A1 [KOIZUMI] See abstract and figures
A	-	CN205297692 U [SINOTRUK] See figures and note English abstract
A	-	US2015/167517 A1 [DONG] See abstract and figures

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

F01N

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

Intellectual Property Office

International Classification:

Subclass	Subgroup	Valid From
F01N	0003/20	01/01/2006
F01N	0003/08	01/01/2006
F01N	0003/10	01/01/2006
F01N	0003/18	01/01/2006
F01N	0009/00	01/01/2006
F01N	0011/00	01/01/2006