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(54) Title: AN APPARATUS WITH A PARTICULATE FILTER AND A THERETO RELATED METHOD

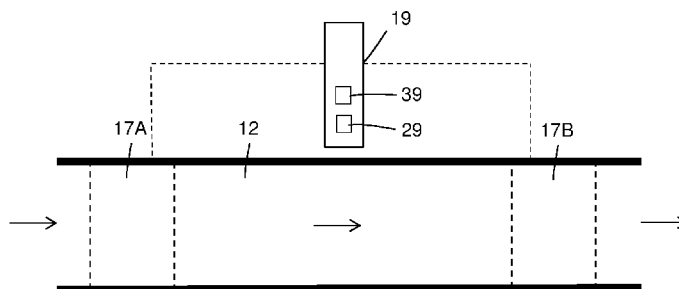


FIG. 3

(57) Abstract: Invention regards an apparatus (5) at least in part to be arranged in a channel (12) for exhaust gas discharged from a combustion engine (4). The apparatus (5) comprises a particulate filter (15) arranged to collect particulate matter present in the exhaust gas, a first pressure sensor (14A) positioned upstream of the particulate filter (15) and a second pressure sensor (14B) positioned downstream of the particulate filter (15). The pressure sensors (14A, 14B) are configured to provide information on the exhaust gas pressure so that a differential pressure across the particulate filter (15) is determined. The apparatus further comprises a particulate matter sensor (17) positioned downstream of the particulate filter (15) and comprising ionizing means (17A) configured to ionize the particulate matter so that an ion current is created in said channel (12) when the exhaust gas carrying the particulate matter is ionized, and detecting means (17B) located downstream of the ionizing means (17A) in said channel (12). The detecting means (17B) are configured to detect the ion current and, in response to the detected ion current, generate a signal comprising information on the particulate matter carried by the exhaust gas. The invention also regards a thereto related method.

An apparatus with a particulate filter and a thereto related method

Technical field

The present invention relates to an apparatus with a particulate filter and a
5 method for managing a particulate filter. It also relates to a vehicle and a
computer program.

Background

Particulate matter (PM) or soot is one of the major harmful emissions generated
10 by diesel engines. In consequence, levels of soot emission are subject to
legislative regulation worldwide. In order to reduce these emissions,
aftertreatment systems, targeting removal of soot from the exhausts, are typically
arranged in connection with modern diesel engines. One of the main components
of such a system is a diesel particulate filter (DPF), normally positioned in an
15 exhaust passage of the combustion engine, downstream of the catalyst. The
aftertreatment systems could also include other types of catalysts such as
oxidation catalysts and selective reduction catalysts for nitrogen oxide removal.

In the related context, research has shown that adverse health effects from
20 exposure to PM are increasing with decreasing particle size. Hence, the
conventional, i.e. mass-based PM-emission limits are in several markets
complemented with emission limits as regards number of the emitted particles.
Above-mentioned DPFs are particularly suitable to adequately treat the exhaust
gas with respect to the number of emitted particles.

25

A DPF is typically made up of a so-called wall-flow monolith, comprising an
extruded, often ceramic, structure with a large number of parallel, axially
extending channels. The adjacent channels in the DPF are alternately plugged at
each end, allowing the exhaust gas to flow through the porous filter walls while
30 capturing the PM.

The amount of soot in the DPF is typically detected indirectly, by means of differential pressure measurement or by soot loading models based on engine operating parameters, such as volume flow rate of the exhaust gas. Here, correlation between the measured differential pressure and the actual soot load
5 may not be sufficiently accurate in order to achieve optimal regeneration timing. This is, at least in part, due to the fact that a change in differential pressure across the filter may be induced by other parameters of the combustion process than soot build-up in the filter. In this context, a certain soot load of the filter is beneficial for its operation - improves filtering properties of the DPF itself by
10 making it more fine-meshed.

In order to, due to excessive PM build-up, avoid large pressure drop over the DPF and the negative effect this has on the fuel economy, the soot is oxidized into carbon dioxide and nitrogen, using oxygen or nitrogen dioxide. This process is
15 called regeneration and can be performed either passively, i.e. without additional energy input using only the exhaust gas stream, or actively, where the exhaust temperature is raised using active engine measures or using fuel injection.

The regeneration process in general, and the continuous process in particular,
20 seek to arrive at a so called soot balance point, where equilibrium between the amount of soot accumulated by the filter and the amount of soot oxidized is achieved. If the oxidation of soot is insufficient, PM build-up will increase, and so will the pressure drop. This pressure drop could trigger active regeneration measures where the accumulated soot load is burnt off the filter by running the
25 engine in a manner that elevates exhaust gas temperature to soot combustion temperatures. Active regeneration, however, consumes fuel and needs to be kept at a minimum.

WO 2011/110920 discloses a system for estimating soot load of a particulate
30 filter. The system comprises two pressure sensors, one on each side of a particulate filter, and, in addition, a device for detecting deposited amount of the particulate matter provided downstream of the filter. The detection device weighs

the deposited particles in order to identify the amount of the deposited particulate. The obtained results, combined with the measured pressure drop, are used to further improve the soot load estimate. Such a device could typically underestimate the number of the emitted particles.

5

In the presented context, the objective of the present invention is to provide an apparatus and a method permitting more precise estimates and a faster response to changes in the soot load of a particulate filter.

10 Summary

The above stated objective is achieved by means of the apparatus, the method, the vehicle and the computer program according to the independent claims.

Accordingly, a first aspect relates to an apparatus at least in part to be arranged in
15 a channel for exhaust gas discharged from a combustion engine, said apparatus comprising: a particulate filter arranged to collect particulate matter present in the exhaust gas, a first pressure sensor positioned upstream of the particulate filter and a second pressure sensor positioned downstream of the particulate filter, said pressure sensors being configured to provide information on the exhaust gas
20 pressure so that a differential pressure across the particulate filter is determined, and a particulate matter sensor positioned downstream of the particulate filter, said sensor comprising: ionizing means configured to ionize the particulate matter so that an ion current is created in said channel when the exhaust gas carrying the particulate matter is ionized, and detecting means located downstream of the
25 ionizing means in said channel, said detecting means being configured to detect the ion current and, in response to the detected ion current, generate a signal comprising information on the particulate matter carried by the exhaust gas.

Positive effects and advantages of the invention at hand are presented below with
30 reference to the first aspect of the invention.

Once the particulate matter traverses the particulate filter, the ionizing effect, applied through the ionizing means, will liberate electrons from atoms or molecules of the particulate matter, thereby creating ions. The exhaust gas comprising ionized particulate matter, i.e. an ion current, subsequently reaches
5 detecting means located in the exhaust gas channel, downstream of the ionizing means. The detecting means will detect the ion current and, in response to the detected ion current, generate a signal comprising information on the particulate matter carried by the exhaust gas. Combining thus obtained information on the filtered, i.e. non-collected, particles with the differential pressure information
10 obtained by means of the pressure sensors gives a more complete understanding of the condition of the particulate filter. This may subsequently be used for various purposes. Ultimately, condition and performance of the particle filter may hereby be calculated with greater accuracy. Also, the present invention allows to more rapidly identify changes to condition and performance of the particle filter.

15 In a related context, more accurate information on the condition of the particulate filter means that the possible need to regenerate the filter may unambiguously be determined sooner and with greater precision. This prolongs useful life of the particle filter and positively impacts on fuel economy.

20 A second aspect relates to a method for managing a particulate filter arranged to collect particulate matter present in exhaust gas discharged from a combustion engine. The method comprises:

- 25
- collecting, by means of a particulate filter, particulate matter present in exhaust gas discharged from a combustion engine,
 - determining a differential pressure across the particulate filter,
 - emitting an ionizing radiation so that an ion current is created when the exhaust gas carrying the particulate matter is
30 contacted by the ionizing radiation,
 - ionizing the exhaust gas carrying the particulate matter so that ion current is created in said channel, and

- detecting the ion current,
- generating, in response to the detected the ion current, a signal comprising information on the particulate matter carried by the exhaust gas.

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A third aspect relates to a vehicle comprising the claimed apparatus.

Different embodiments of the invention are disclosed in the dependent claims and in the detailed description.

10

Brief description of the drawings

Fig. 1 is a schematical view from above of a vehicle.

Fig. 2 is a contextual, schematical view of an apparatus according to one embodiment of the present invention, said apparatus comprising a particulate filter, two pressure sensors and a particulate matter sensor.

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Fig. 3 schematically illustrates the operation of a particulate matter sensor of the present invention.

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Fig. 4 is a flow chart comprising method steps according to one embodiment of the present invention.

Further advantages and features of embodiments will become apparent when reading the following detailed description in conjunction with the drawings.

25

Detailed description

The present invention will now be described more fully, hereinafter with reference to the accompanying drawings, in which preferred embodiments are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete,

30

and will fully convey the scope of the invention to those skilled in the art. In the drawings, like reference signs refer to like elements.

Fig. 1 is a schematical view from above of a vehicle 1. The shown vehicle 1 is a truck or a trailer-hauling tractor having a chassis 9 and a front pair of wheels 10A and a rear pair of wheels 10B. The shown vehicle 1 is only an example, why the vehicle of the present invention may also be realized as a bus or a thereto similar vehicle. A driver's cab 7 is positioned far forward on the vehicle 1. A control unit 19, located below the driver's cab 7, controls the operation state of an internal combustion engine 4 in accordance with the operating condition of the combustion engine 4 and/or driver inputs. Exhaust gases generated during the combustion process are channeled into an exhaust system 11 for further treatment. Accordingly and as schematically shown in Fig. 1, the combustion engine 4 is in fluid communication with the exhaust system 11. This further treatment of the exhaust gases could also be controlled by the control unit 19. Certain constituents of the exhaust system 11 will be discussed in greater detail in connection with Figs. 2 and 3.

The present inventive apparatus (not shown in Fig. 1) is suitable for implementation in the vehicles of the above-discussed kind. Moreover, the apparatus may be implemented in other fields where particle filters are arranged in connection with combustion engines, e.g. marine engines, locomotives and/or stationary power plants.

Fig. 2 is a contextual, schematical view of an inventive apparatus 5 according to one embodiment of the present invention. The apparatus 5 is arranged downstream of a catalyst 13 in a channel 12 for exhaust gas discharged from a combustion engine 4. The apparatus 5 comprises a particulate filter 15 arranged to collect particulate matter present in the exhaust gas. A first pressure sensor 14A is positioned upstream of the particulate filter 15 and a second pressure sensor 14B is positioned downstream of the particulate filter 15. The pressure sensors 14A, 14B measure the exhaust gas pressure. These pressure sensors

14A, 14B are configured to provide information on the exhaust gas pressure so that a differential pressure across the particulate filter 15 is determined.

A particulate matter sensor 17 is positioned downstream of the particulate filter
5 15. The particulate matter sensor 17 will be more thoroughly discussed in connection with Fig. 3. The apparatus 5 further comprises a control unit 19. Various sensors, such as pressure sensors 14A, 14B, exhaust gas temperature sensors (not shown) and the like, are connected to the control unit 19. Output signals from these sensors are input to the control unit 19. The control unit 19 will
10 also be discussed in more detail in connection with Fig. 3.

Fig. 3 schematically illustrates the operation of a particulate matter sensor 17 of the present invention. The sensor 17 comprises ionizing means 17A and detecting means 17B, both arranged in a channel 12 for exhaust gas discharged from a
15 combustion engine (not shown). Flow direction of the exhaust gas is denoted by arrows. The ionizing means 17A are configured to ionize the particulate matter so that an ion current is created in said channel 12 when the exhaust gas carrying the particulate matter is ionized. The ionizing effect, applied through the ionizing means, will liberate electrons from atoms or molecules of the particulate matter,
20 thereby creating ions. In an embodiment (not shown), the ionizing means 17A comprises a device generating an electric field. By way of example, this device could comprise a pair of oppositely charged elements facing each other such that an electric field is created between these elements. The particulate matter passes between the elements and is exposed to this electric field. In a further
25 embodiment (not shown), the ionizing means 17A comprises a robust and suitably arranged radiation source, such as a UV-light source or an X-ray-source.

The exhaust gas comprising ionized particulate matter, i.e. carrying an ion current, subsequently reaches detecting means located in the exhaust gas channel,
30 downstream of the ionizing means. The detecting means 17B are configured to detect the ion current and, in response to the detected ion current, generate a signal comprising information on the particulate matter carried by the exhaust gas.

Combining thus obtained information on the filtered, i.e. non-collected, particles with the differential pressure information obtained by means of the pressure sensors gives a more complete understanding of the condition of the particulate filter.

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In an embodiment (not shown), the detecting means 17B comprises a net-shaped structure made in conductive material, said net-shaped structure being arranged radially in said channel 12 for exhaust gas. The travelling ionized particles will eventually contact the net-shaped structure whereupon a current signal is

10 generated in the structure. The current signal is harvested and treated using usual methods known to the person skilled in the art.

In a further embodiment (not shown), the detecting means 17B comprises a coil arranged axially in said channel 12 for exhaust gas. The coil delimits an axially
15 extending core section. Some of the travelling ionized particles will longitudinally traverse the core section, thus inducing a voltage signal in the coil. Analogously to the above, the voltage signal is harvested and treated using usual methods known to the person skilled in the art.

20 A control unit 19 typically has a processing unit 29 and a memory unit 39 connected to the processing unit 29. The processing unit 29 may comprise one or several CPUs (CPU – Central Processing Unit). The memory unit 39 could be of the non-volatile kind, e.g. a flash memory, or a RAM-memory (RAM – Random Access Memory). The processing unit 29 is configured to carry out the instructions
25 of the computer program P with computer instructions. The computer program P could be recorded on a carrier, typically a computer readable medium, prior to being loaded onto the memory unit 39. Alternatively, it could be preinstalled in said memory unit 39.

30 Still with reference to the control unit 19, it may be configured to determine, on the basis of the detected ion current, the number of particles that make up the particulate matter carried by the exhaust gas. As an alternative, this functionality,

realized through dedicated means for determining the number of particles that make up the particulate matter, may be integrated in the apparatus 5.

5 In a related embodiment, the control unit 19 may be configured to establish size distribution of the particles that make up the particulate matter carried by the exhaust gas. This is typically achieved using previously obtained data regarding the number of particles that make up the particulate matter. Information regarding size distribution of the particles may inter alia be used in order to fine-tune regeneration cycles. As an alternative, the apparatus 5 may comprise said means
10 for establishing size distribution of the particles that make up the particulate matter.

In yet another embodiment, the control unit 19 may be configured to estimate soot load of the particle filter. This is typically achieved using previously obtained data
15 regarding the size distribution of the particles. Furthermore, the control unit 19 may be configured to compare the estimated soot load value of the particulate filter 15 to a referential soot load value. Here, regeneration of the particulate filter 15 is initiated if the estimated soot load value of the particulate filter 15 differs from the referential soot load value. The referential soot load value may be a
20 single value or it may be expressed as an interval. Alternatively, means for estimating soot load of the particulate filter may be employed in order to calculate the soot load estimate, said means being part of the apparatus 5.

In this context, regeneration of the particulate filter can occur by soot oxidation of
25 the trapped particles either with oxygen (active regeneration) or nitrogen dioxide (passive regeneration) – both briefly discussed in the Background-section. For active regeneration, exhaust gas temperatures need to be temporarily increased by suitable manipulation of the combustion engine or by injection of additional fuel directly into the exhaust channel upstream a catalyst. Passive regeneration
30 occurs at temperatures as low as 250°C and can thus regenerate the particulate filter continuously.

The control unit 19 may initiate either active or passive regeneration of the particle filter. Moreover, it may combine time periods of active regeneration and time periods of passive regeneration in order to ensure a proper regeneration of the particulate filter. When it comes to active regeneration, initiation is synonymous
5 with supplying extra fuel into the exhaust channel 12. The extra fuel may be supplied by adding, via a fuel addition valve (not shown), the fuel into the exhaust gas or by performing a supplemental fuel injection, which differs from the ordinary, scheduled fuel injection of the combustion engine.

10 Alternatively, the control unit 19 may be configured to generate an indicative signal if above criterion is fulfilled. The indicative signal signifies that the particulate filter requires regeneration. In this context, filter regeneration should generally occur without involving the driver, including without informing him/her that a regeneration process is ongoing.

15 The above-described control unit 19 controls various actuators, such as fuel injection valves and the fuel addition valve. This may be implemented in various manners that are known to those of skill in the art and, for that reason, are not described in detail herein.

20 Fig. 4 is a flow chart comprising method steps according to one embodiment of the present invention. The flow chart shows a method for an apparatus with a particulate filter previously described in connection with Figs. 1-3.

25 The method comprises collecting 40, by means of a particulate filter 15, particulate matter present in exhaust gas discharged from a combustion engine 4. A differential pressure across the particulate filter 15 is subsequently determined 50. An ionizing radiation is thereafter emitted 60 so that an ion current is created when the exhaust gas carrying the particulate matter is contacted by the ionizing
30 radiation. The exhaust gas carrying the particulate matter is thereafter ionized 70 so that an ion current is created in said channel 12. Finally, the ion current is

detected 80, and a signal is generated 90, in response to the detected ion current, said comprising information on the particulate matter carried by the exhaust gas.

In addition, the number of particles that make up the particulate matter carried by the exhaust gas may be determined on the basis of the detected ion current.

The previously obtained data regarding the number of particles may be used to establish size distribution of the particles that make up the particulate matter carried by the exhaust gas. In the related context and in order to establish the condition of the particulate filter, soot load of the particulate filter may thereafter be estimated using data regarding size distribution of the particles.

Hereby estimated soot load value of the particulate filter 15 may be compared to a referential soot load value. This referential value could be based on the historical data as regards condition of the particulate filter. In consequence, an indicative signal could be generated if the estimated soot load value of the particulate filter differs from the referential soot load value, said indicative signal signifying that the particulate filter requires regeneration. Various regenerative processes available are thoroughly described in connection with Fig. 3.

The present invention also relates to a computer program P that comprises a computer program code to cause the previously discussed control unit, or a computer connected to the control unit, to perform the method described above. In addition, a computer program product is provided comprising a computer program code stored on a computer-readable medium to perform the method described above, when the computer program code is executed by the control unit or by a computer connected to the control unit.

In the drawings and specification, there have been disclosed typical preferred embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention being set forth in the following claims.

Claims

1. An apparatus (5) at least in part to be arranged in a channel (12) for exhaust gas discharged from a combustion engine (4), said apparatus (5) comprising:
- 5 a particulate filter (15) arranged to collect particulate matter present in the exhaust gas,
- 10 a first pressure sensor (14A) positioned upstream of the particulate filter (15) and a second pressure sensor (14B) positioned downstream of the particulate filter (15), said pressure sensors (14A, 14B) being configured to provide information on the exhaust gas pressure so that a differential pressure across the particulate filter (15) is determined, and
- 15 a particulate matter sensor (17) positioned downstream of the particulate filter (15), wherein said sensor (17) comprises:
- 20 ionizing means (17A) configured to ionize the particulate matter so that an ion current is created in said channel (12) when the exhaust gas carrying the particulate matter is ionized, and
- 25 detecting means (17B) located downstream of the ionizing means (17A) in said channel (12), said detecting means (17B) being configured to detect the ion current and, in response to the detected ion current, generate a signal comprising information on the particulate matter carried by the exhaust gas,
- wherein the apparatus (5) further comprises:
- 30 means for determining, on the basis of the detected ion current, the number of particles that make up the particulate matter carried by the exhaust gas and

means for establishing size distribution of the particles that make up the particulate matter carried by the exhaust gas.

5 2. An apparatus (5) according to claim 1, wherein the ionizing means (17A) comprises a device generating an electric field.

3. An apparatus (5) according to claim 1, wherein the ionizing means (17A) comprises a radiation source, such as a UV-light source or an X-ray-source.

10 4. An apparatus (5) according to any of preceding claims, wherein the detecting means (17B) comprises a net-shaped structure made in conductive material, said net-shaped structure being arranged radially in said channel (12) for exhaust gas.

15 5. An apparatus (5) according to any of claims 1-3, wherein the detecting means (17B) comprises a coil arranged axially in said channel (12) for exhaust gas.

20 6. An apparatus (5) according to any of the preceding claims, wherein the apparatus (5) further comprises means for estimating soot load of the particulate filter.

25 7. An apparatus (5) according to claim 1, the apparatus (5) further comprising a control unit (19) being configured to:

- determine, on the basis of the detected ion current, the number of particles that make up the particulate matter carried by the exhaust gas.

30 8. An apparatus (5) according to claim 7, the control unit (19) further being configured to:

- establish size distribution of the particles that make up the particulate matter carried by the exhaust gas.

5 9. An apparatus (5) according to claim 8, the control unit (19) further being configured to:

- estimate soot load of the particulate filter.

10 10. An apparatus (5) according to claim 9, the control unit (19) further being configured to:

- compare the estimated soot load value of the particulate filter (15) to a referential soot load value, and
- initiate regeneration of the particulate filter (15), if the estimated soot load value of the particulate filter (15) differs from the referential soot load value.

20 11. A vehicle (1) comprising an apparatus (5) according to any of preceding claims.

12. A method comprising the steps of:

- collecting (40), by means of a particulate filter (15), particulate matter present in exhaust gas discharged from a combustion engine (4),
- 25 - determining (50) a differential pressure across the particulate filter (15),
- emitting (60) an ionizing radiation so that an ion current is created when the exhaust gas carrying the particulate matter is contacted by the ionizing radiation,
- ionizing (70) the exhaust gas carrying the particulate matter so that an ion current is created in said channel (12),
- 30 - detecting (80) the ion current,

- generating (90), in response to the detected ion current, a signal comprising information on the particulate matter carried by the exhaust gas,

5 the method further comprising the steps of:

- determining, on the basis of the detected ion current, the number of particles that make up the particulate matter carried by the exhaust gas, and

10

- establishing size distribution of the particles that make up the particulate matter carried by the exhaust gas.

13. A method according to claim 12, further comprising the step of:

15

- estimating soot load of the particulate filter.

14. A method according to claim 13, further comprising the step of:

20

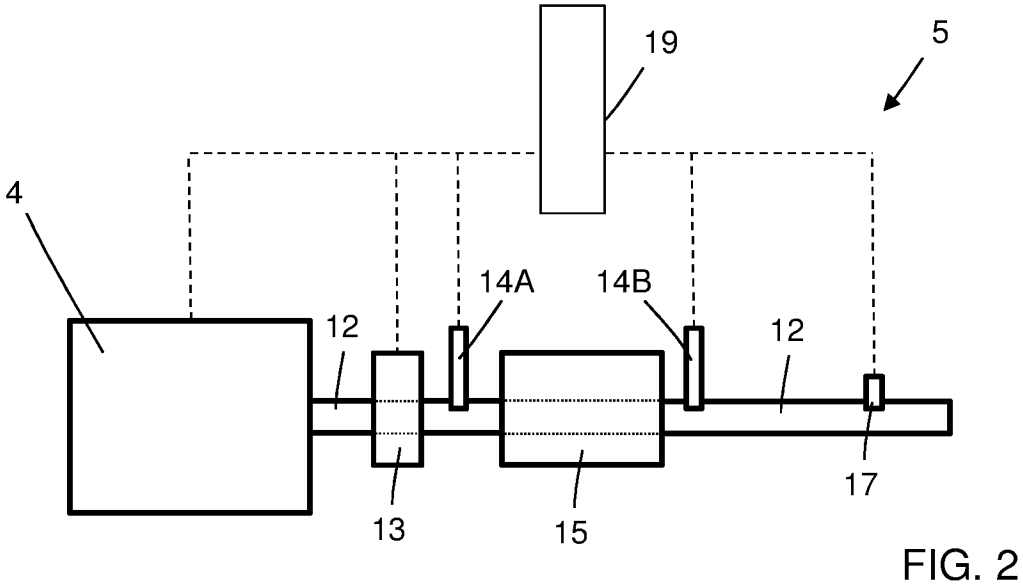
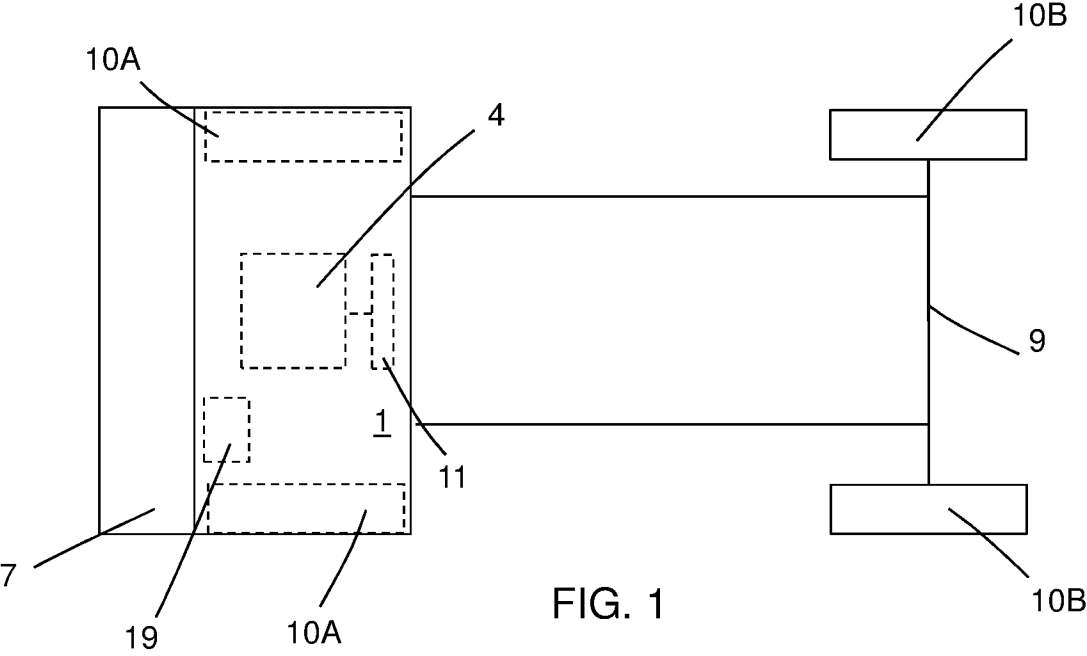
- comparing the estimated soot load value of the particulate filter (15) to a referential soot load value, and

- generating an indicative signal, if the estimated soot load value of the particulate filter (15) differs from the referential soot load value, said indicative signal signifying that the particulate filter (15) requires regeneration.

25

15. A computer program P, wherein said computer program P comprises a computer program code to cause a control unit (19), or a computer
30 connected to the control unit (19), to perform the method according to any of claims 12-14.

16. A computer program product comprising a computer program code stored on a computer-readable medium to perform the method according to any of the claims 12-14, when the computer program code is executed by a control unit (19) or by a computer connected to the control unit (19).



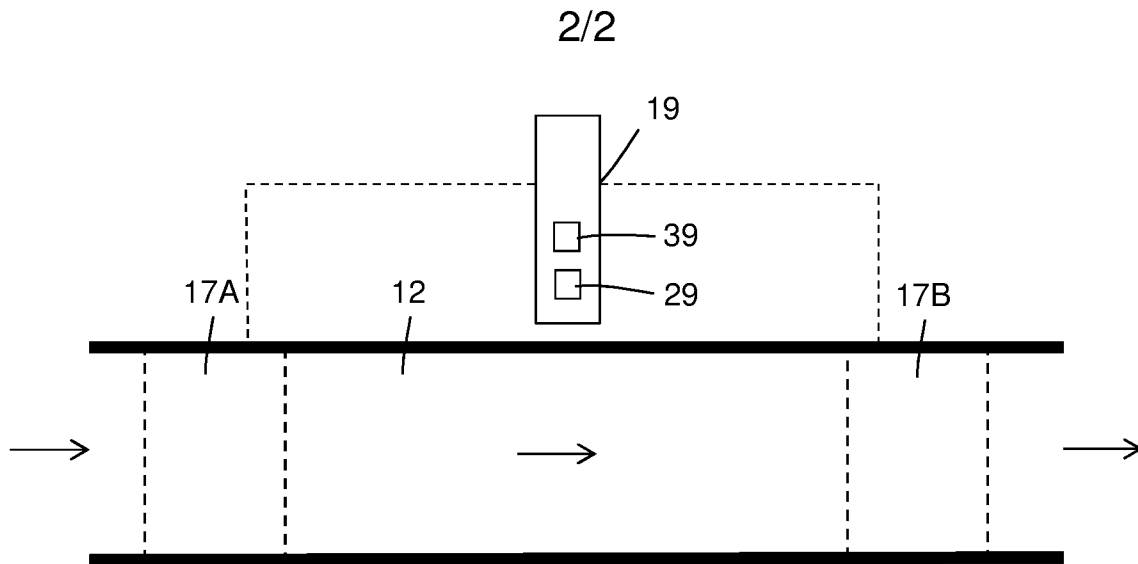


FIG. 3

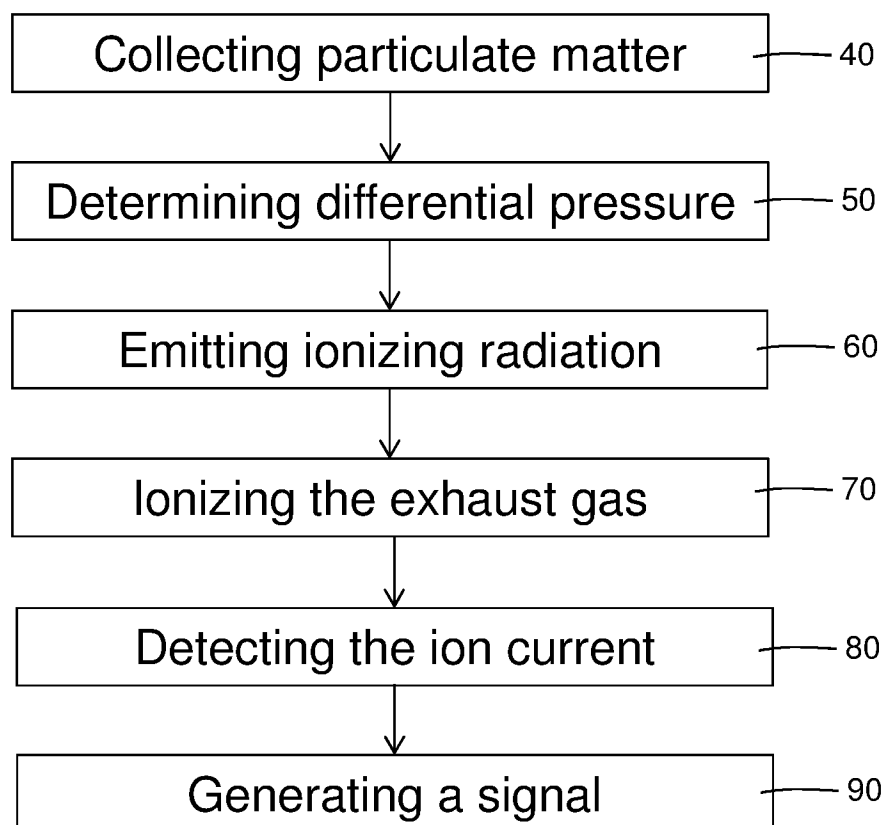


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2016/050191

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, G01N

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.
A	US 20120324841 A1 (NISHIJIMA HIROKI), 27 December 2012 (2012-12-27); paragraphs [0005], [0035]-[0038]; figure 1 --	1-16
A	US 20060156791 A1 (TIKKANEN JUHA ET AL), 20 July 2006 (2006-07-20); column 0004; paragraphs [0012], [0032]-[0034], [0036]; figure 1 --	1-16
A	US 20150020574 A1 (MOTOMURA MASAYUKI ET AL), 22 January 2015 (2015-01-22); paragraphs [0117]-[0141]; figures 1, 7, 8 --	1-16

☒ 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

“E” earlier application or patent but published on or after the international filing date

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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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Date of the actual completion of the international search

19-05-2016

Date of mailing of the international search report

20-05-2016

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Patent- och registreringsverket

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INTERNATIONAL SEARCH REPORT

International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 20130086888 A1 (LEE JIN HA ET AL), 11 April 2013 (2013-04-11); paragraphs [0006], [0033]-[0042]; figures 1, 2 --	1-16
A	US 20110050243 A1 (TIKKANEN JUHA), 3 March 2011 (2011-03-03); paragraphs [0023], [0039]; figure 1 -- -----	1-16

Continuation of: second sheet

International Patent Classification (IPC)

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F01N 3/021 (2006.01)

F01N 11/00 (2006.01)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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