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(54) Title: EXHAUST SYSTEM FOR A VEHICLE

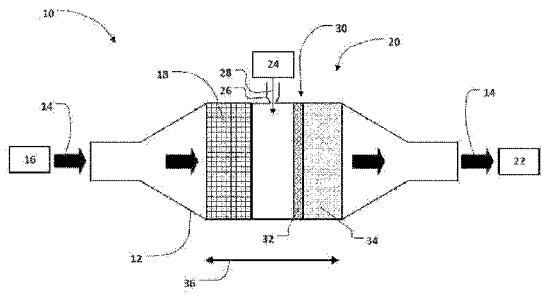


FIGURE 1

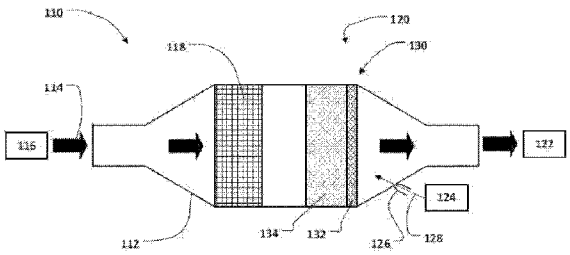


FIGURE 2

(57) Abstract: An exhaust system (10) for a vehicle includes a passageway (12), a selective catalytic reduction system (22), a diesel particulate filter (20), an urea injection system (24), and a hydrolysis catalyst (32). The passageway (12) is operable to direct a flow of exhaust gas emitted from an engine (16) of the vehicle. The selective catalytic reduction system (22)(SCR) and the diesel particulate filter (20)(DPF) are positioned along the passageway spaced from one another. Optionally a oxidation catalyst (can be positioned upstream of the diesel particulate filter (20). At least a portion (32) of the diesel particulate filter (20) is coated with a hydrolysis catalyst coating (30). The urea injection system (24) includes an injection port (26) positioned along the passageway upstream or alternatively downstream of the selective catalytic reduction system (22) and is operable to inject urea towards the hydrolysis catalyst coating (30) on the diesel particulate filter (20). Urea injected decomposes into ammonia and carbon dioxide upon contact with the hydrolysis catalyst. Thus, the decomposition of the urea is not dependent on mixing the urea with the exhaust gases.

EXHAUST SYSTEM FOR A VEHICLE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit of U.S. Patent Application Serial No. 14/301,707 filed on June 11, 2014. The disclosure of the above application is incorporated herein by reference in its entirety.

FIELD

[0001] The present disclosure relates generally to an exhaust system for a vehicle, such as an exhaust system operable to remove nitrogen oxides and particulate matter from exhaust gases.

BACKGROUND

[0002] It is desirable to eliminate nitrogen oxides (NO_x) and particulate matter contained in exhaust gas emitted from internal combustion engines. One of the methods for purifying exhaust gas includes the step of injecting aqueous urea into the exhaust passageway to generate ammonia by hydrolysis. The urea decomposes into ammonia and carbon dioxide by being intermixed with the relatively hot and moisture-rich exhaust gas. The ammonia is then utilized with a nitrogen oxide catalyst, such as a selective catalytic reduction (SCR) type catalyst. The nitrogen oxide is decomposed into nitrogen and water. Effective decomposition of the urea often requires that the system includes a mixer, or that the system provides sufficient time for mixing, resulting in increased system length. In medium-duty applications, the temperature of the exhaust gas can fall below 200°C and compromise urea decomposition. For example, the water component of the aqueous urea evaporates before the urea decomposes. The urea then crystallizes and forms undesirable deposits within the system. Thus, while current exhaust systems work for their intended purpose, there remains a need for improvement in the relevant art.

SUMMARY

[0003] In one form, an exhaust system for a vehicle is provided in accordance with the teachings of the present disclosure. In an exemplary implementation, an exhaust system for a vehicle includes a passageway, a selective catalytic reduction system, a diesel particulate filter, a urea injection system, and a hydrolysis catalyst. The passageway is operable to direct a flow of exhaust gas emitted from an engine of the vehicle. The selective catalytic reduction system and the diesel particulate filter are positioned along the passageway spaced from one another. The urea injection system includes an injection port positioned along the passageway upstream of the selective catalytic reduction system. The urea injection system is operable to inject urea into the passageway. The hydrolysis catalyst coats at least a portion of the diesel particulate filter. Urea injected into the passageway through the injection port decomposes into ammonia and carbon dioxide upon contact with the hydrolysis catalyst. Thus, the decomposition of the urea is not dependent on mixing the urea with the exhaust gases.

[0004] In another form, a method of treating exhaust from an engine is provided in accordance with the teachings of the present disclosure. In an exemplary implementation, method includes the step of arranging a passageway to direct the flow of exhaust. The method also includes the step of positioning a selective catalytic reduction system and a diesel particulate filter along the passageway to treat the exhaust. The method also includes the step of positioning an injection port of a urea injection system along the passageway to inject urea into the passageway upstream of the selective catalytic reduction system. The method also includes the step of coating at least a portion of the diesel particulate filter with a hydrolysis catalyst. Urea injected into the passageway through the injection port decomposes into ammonia and carbon dioxide upon contact with the hydrolysis catalyst. As a result, the decomposition of the urea is not dependent on mixing the urea with the exhaust gases.

[0005] In some implementations, the positioning of the hydrolysis catalyst can be varied. For example, the hydrolysis catalyst can be arranged on the diesel particulate filter proximate to the injection port rather than on the entire diesel

particulate filter. As a result, a quantity of hydrolysis catalyst applied to the diesel particulate filter can be minimized. In addition, the position of the injection port can be arranged such that the urea is injected at least partially against the flow of exhaust. This can enhance the distribution of urea about the coated portion of the diesel particulate filter.

[0006] Further areas of applicability of the teachings of the present disclosure will become apparent from the detailed description, claims and the drawings provided hereinafter, wherein like reference numerals refer to like features throughout the several views of the drawings. It should be understood that the detailed description, including disclosed embodiments and drawings referenced therein, are merely exemplary in nature, intended for purposes of illustration only and are not intended to limit the scope of the present disclosure, its application or uses. Thus, variations that do not depart from the gist of the present disclosure are intended to be within the scope of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 is a schematic view of a first exemplary exhaust system for a vehicle according to the principles of the present disclosure; and

[0008] Figure 2 is a schematic view of a second exemplary exhaust system for a vehicle according to the principles of the present disclosure.

DESCRIPTION

[0009] With initial reference to Figure 1, an exemplary exhaust system for a vehicle is schematically shown and generally identified at reference numeral 10. In the exemplary implementation illustrated, exhaust system 10 includes a passageway 12 to direct the flow of exhaust gas. Exhaust gas is referenced in the Figures by arrows, such as arrow 14. Exhaust gas 14 is received from an engine 16. The engine 16, in the exemplary implementation, is a diesel engine.

[0010] With continued reference to Figure 1, the exhaust system 10 includes a diesel oxidation catalyst 18 in the exemplary implementation. The diesel oxidation catalyst 18 is operable to oxidize several exhaust gas components within

the exhaust gas 14, including carbon monoxide, gas phase hydrocarbons, and the organic fraction of diesel particulates. The diesel oxidation catalyst 18 is also operable to reduce the odor of the exhaust gas 14.

[0011] With continued reference to Figure 1, the exhaust system 10 also includes a diesel particulate filter 20 positioned along the passageway 12. The diesel particulate filter 20 is positioned downstream of the diesel oxidation catalyst 18 along the passageway 12 in the exemplary implementation. The diesel particulate filter 20 is operable to remove or accumulate diesel particulate matter or soot from the exhaust gas 14. The diesel particulate filter 20 is operable to facilitate burning off the accumulated particulate matter. For example, the diesel particulate filter 20 may burn off accumulated particulate through the use of a catalyst or with a fuel burner that heats the diesel particulate filter 20 to a combustion temperature of the particulate.

[0012] With continued reference to Figure 1, the exhaust system 10 also includes a selective catalytic reduction system 22. The selective catalytic reduction system 22 is spaced downstream from the diesel particulate filter 20. The selective catalytic reduction system 22 is operable to convert nitrogen oxides within the exhaust gas 14 into diatomic nitrogen and water.

[0013] With continued reference to Figure 1, the exhaust system 10 also includes a urea injection system 24. The urea injection system 24 includes an injection port 26 positioned along the passageway 12 upstream of the selective catalytic reduction system 22. The urea injection system 24 is operable to inject urea into the passageway 12. The injected urea is referenced at 28. In one exemplary implementation, the diesel particulate filter 20 is positioned downstream and spaced from the diesel oxidation catalyst 18 and the urea 28 is injected into the space between the diesel oxidation catalyst 18 and the diesel particulate filter 20. The urea 28 is a reductant and is utilized in the selective catalytic reduction system 22 to decompose nitrogen oxides into nitrogen and water. However, the urea 28 itself is first decomposed by a catalyst.

[0014] Effective decomposition of the urea in current exhaust systems requires that the urea sufficiently mix with the exhaust gas. Sufficient mixing in

current exhaust systems is achieved by extending the length of the system in order to increase the amount of time that the urea and the exhaust intermix prior to encountering the selective catalytic reduction system. The extended length increases costs and compromises packaging efficiency of current exhaust systems. Some current systems include a mixer to reduce the amount of extended length. However, the mixer does not eliminate the need for extended length and also increases the cost and complexity of current exhaust systems. Another challenge associated with effective intermixing of urea and exhaust arises in medium-duty applications. In these applications, the temperature of the exhaust gas can fall below 200°C, which compromises urea decomposition. In such medium-duty systems, the water component of the aqueous urea evaporates before the urea decomposes. As a result, at least some portion of the urea crystallizes and forms deposits within the system.

[0015] With continued reference to Figure 1, the exhaust system 10 in the exemplary implementation includes a hydrolysis catalyst coating 30 on at least a portion of the diesel particulate filter 20. In the exemplary implementation illustrated, the diesel particulate filter 20 includes a first portion 32 that is coated with the hydrolysis catalyst coating 30 and a second portion 34 that is not coated with the hydrolysis catalyst coating 30. In the exemplary implementation illustrated, the first portion 32 is upstream of the second portion 34 and is facing the space between the diesel oxidation catalyst 18 and the diesel particulate filter 20. The urea 28 that is injected into the passageway 12 through the injection port 26 decomposes into ammonia and carbon dioxide upon contact with the hydrolysis catalyst coating 30. Thus, the exhaust system 10 is not dependent on the extent of intermixing between the exhaust gas 14 and the urea 28.

[0016] With continued reference to Figure 1, the hydrolysis catalyst coating 30, in one exemplary implementation, is titanium oxide and is wash-coated on the diesel particulate filter 20. After the urea 28 decomposes, the components of the urea 28, ammonia and carbon dioxide, travel along the passageway 12 with the exhaust gas 14 from the diesel particulate filter 20 to the selective catalytic reduction system 22. The components of the urea 28 are utilized at the selective

catalytic reduction system 22 to convert nitrogen oxides within the exhaust gas 14 into diatomic nitrogen and water.

[0017] With continued reference to Figure 1, the hydrolysis catalyst coating 30 coats less than a full length of the diesel particulate filter 20 along the passageway 12 in the exemplary implementation. The passageway 12 extends along an axis 36, and the first portion 32 extends less than half of the full length of the diesel particulate filter 20 along the axis 36 in the exemplary implementation. The hydrolysis catalyst coating 30 coats less than one quarter of the diesel particulate filter 20 along the axis 36 in the exemplary implementation. In other implementations, the extent of the hydrolysis catalyst coating 30 on the diesel particulate filter 20 can be selected in view of operation conditions. For example, the extent of coating can be increased if the conversion of nitrogen oxides within the exhaust gas 14 into diatomic nitrogen and water is less than complete. Also, the thickness of the coating can be chosen in view of the desired or expected useful life of the diesel particulate filter 20.

[0018] With initial reference to Figure 2, an exemplary exhaust system for a vehicle is schematically shown and generally identified at reference numeral 110. The exhaust system 110 includes a passageway 112 to direct the flow of exhaust gas 114 received from an engine 116. The exhaust system 110 also includes a diesel oxidation catalyst 118, a diesel particulate filter 120, a selective catalytic reduction system 122, and a urea injection system 124. The urea injection system 124 includes an injection port 126 positioned along the passageway 112 upstream of the selective catalytic reduction system 122 and downstream of the diesel particular filter 120. The urea injection system 124 is operable to inject urea 128 into the passageway 112.

[0019] With continued reference to Figure 2, the exhaust system 110 in the exemplary implementation includes a hydrolysis catalyst coating 130 a first portion 132 of the diesel particulate filter 120. A second portion 134 of the diesel particulate filter 20 is uncoated. The urea 128 that is injected into the passageway 112 through the injection port 126 decomposes into ammonia and carbon dioxide upon contact with the hydrolysis catalyst coating 130. After the urea 128

decomposes, the components of the urea 128 travel along the passageway 112 with the exhaust gas 114 from the diesel particulate filter 120 to the selective catalytic reduction system 122 and are utilized to convert nitrogen oxides within the exhaust gas 114 into diatomic nitrogen and water.

[0020] With continued reference to Figures 1 and 2, only one of a rearward portion and a forward portion of a diesel particulate filter can be coated with the hydrolysis catalyst in various implementations of the present disclosure. The portion of the diesel particulate filter closest to the injection port can be coated with the hydrolysis catalyst to minimize the extent of coating required. Further, the pattern of the coating on the diesel particulate filter can be selected in view of the relative directions and strengths of the flows of exhaust gas and urea. For example, the interaction of the flows of exhaust and urea can result in a dispersion pattern of the urea solution on the diesel particulate filter. This dispersion pattern can be predicted, for example, using computational fluid dynamics software. The hydrolysis catalyst can be coated on the diesel particulate filter in a pattern predicted by the computational fluid dynamics software.

[0021] With continued reference to Figure 1, the hydrolysis catalyst coating 30 coats a leading edge of the diesel particulate filter 20 along the passageway 12. The injection port 26 is arranged to direct urea 28 into the passageway 12 in a direction that is transverse to a direction of exhaust flow 14. The injection port 26 is perpendicular to the direction of the exhaust flow 14. The interaction between the flow of urea 28 and the exhaust 14, as well as the flow dynamics associated with the port 26, allow the urea 28 to disperse across the first portion 32 of the diesel particulate filter 20. The dispersed urea 28 contacts the coating of hydrolysis catalyst coating 30 on the first portion 32 and decomposes. The components of the urea 28, ammonia and carbon dioxide, then pass through the remainder of the diesel particulate filter 20 with the exhaust 14.

[0022] With continued reference to Figure 2, the hydrolysis catalyst coating 130 coats a trailing edge of the diesel particulate filter 120 along the passageway 112. The injection port 126 is arranged to direct urea 128 into the passageway 112 in a direction that is transverse to a direction of exhaust flow 114.

The direction of the injection port 126 is partially opposite to the direction of exhaust flow 14. In other words, a vector component of the flow of urea 128 is opposite to the corresponding vector component of the flow of exhaust 114. The urea 128 is directed partially upstream of the passageway 112, and the exhaust 114 flows downstream. The interaction between the flow of urea 128 and the exhaust 114, as well as the flow dynamics of the port 126, allow the urea 128 to disperse across the first portion 132 of the diesel particulate filter 120. The dispersed urea 128 contacts the coating of hydrolysis catalyst coating 130 on the first portion 132 and decomposes. The components of the urea 128, ammonia and carbon dioxide, then pass through the remainder of the diesel particulate filter 120 with the exhaust 114.

[0023] It should be understood that the mixing and matching of features, elements, methodologies and/or functions between various examples may be expressly contemplated herein so that one skilled in the art would appreciate from the present teachings that features, elements and/or functions of one example may be incorporated into another example as appropriate, unless described otherwise above.

CLAIMS

What is claimed is:

1. An exhaust system for a vehicle comprising:

a passageway operable to direct a flow of exhaust gas emitted from an engine of the vehicle;

a selective catalytic reduction system positioned along the passageway;

a diesel particulate filter positioned along the passageway spaced from the selective catalytic reduction system;

a urea injection system including an injection port positioned along the passageway upstream of the selective catalytic reduction system, the urea injection system operable to inject urea into the passageway; and

a hydrolysis catalyst coating on at least a portion of the diesel particulate filter, wherein urea injected into the passageway through the injection port decomposes into ammonia and carbon dioxide upon contact with the hydrolysis catalyst.

2. The exhaust system of claim 1 wherein the hydrolysis catalyst coating coats less than a full length of the diesel particulate filter along the passageway.

3. The exhaust system of claim 2 wherein the hydrolysis catalyst coating coats a leading edge of the diesel particulate filter along the passageway.

4. The exhaust system of claim 3, wherein the urea injection system is positioned upstream of and adjacent to the leading edge of the diesel particulate filter.

5. The exhaust system of claim 4, wherein the exhaust system further comprises a diesel oxidation catalyst positioned along the passageway upstream of

and spaced from the diesel particulate filter, and wherein the urea injection system is positioned between the diesel oxidation catalyst and the diesel particulate filter.

6. The exhaust system of claim 2 wherein the hydrolysis catalyst coating coats less than one quarter of the full length of the diesel particulate filter along the passageway.

7. The exhaust system of claim 1 wherein the injection port directs urea into the passageway in a direction transverse to a direction of exhaust flow.

8. The exhaust system of claim 7 wherein the direction of the injection port is perpendicular to the direction of the exhaust flow.

9. The exhaust system of claim 2 wherein the hydrolysis catalyst coating coats a trailing edge of the diesel particulate filter along the passageway.

10. The exhaust system of claim 9, wherein the urea injection system is positioned downstream of and adjacent to the trailing edge of the diesel particulate filter.

11. The exhaust system of claim 10 wherein a direction of the injection port is at least partially opposite to a direction of exhaust flow.

12. A method of treating exhaust emitted from an engine comprising the steps of:

providing a passageway to direct a flow of exhaust gas;

providing a selective catalytic reduction system and a diesel particulate filter along the passageway to treat the exhaust;

providing an injection port of a urea injection system along the passageway to inject urea into the passageway upstream of the selective catalytic reduction system; and

providing a hydrolysis catalyst coating on at least a portion of the diesel particulate filter such that urea injected into the passageway through the injection port decomposes into ammonia and carbon dioxide upon contact with the hydrolysis catalyst.

13. The method of claim 12 further comprising the step of:

injecting the urea in a direction at least partially opposite to a flow of exhaust gas through the passageway to enhance a dispersion of the urea.

14. The method of claim 12 wherein the step of providing the hydrolysis catalyst coating is further defined as:

providing the hydrolysis catalyst coating on only one of a rearward portion and a forward portion of the diesel particulate filter, the portion closest to the injection port.

15. The method of claim 12 further comprising the step of:

providing a diesel oxidation catalyst along the passageway to treat the exhaust, upstream of the diesel particulate filter, the selective catalytic reduction system, and the injection port.

16. The method of claim 15 further comprising the step of:

providing the injection port between the diesel oxidation catalyst and the diesel particulate filter.

17. The method of claim 12 wherein the step of providing a hydrolysis catalyst coating on at least a portion of the diesel particulate filter is further defined as providing the hydrolysis catalyst coating on at least a portion of the diesel particulate filter such that urea injected into the passageway through the injection port decomposes into ammonia and carbon dioxide upon contact with the hydrolysis catalyst coating, such that decomposition of the urea is not dependent on mixing the urea with the exhaust gas.

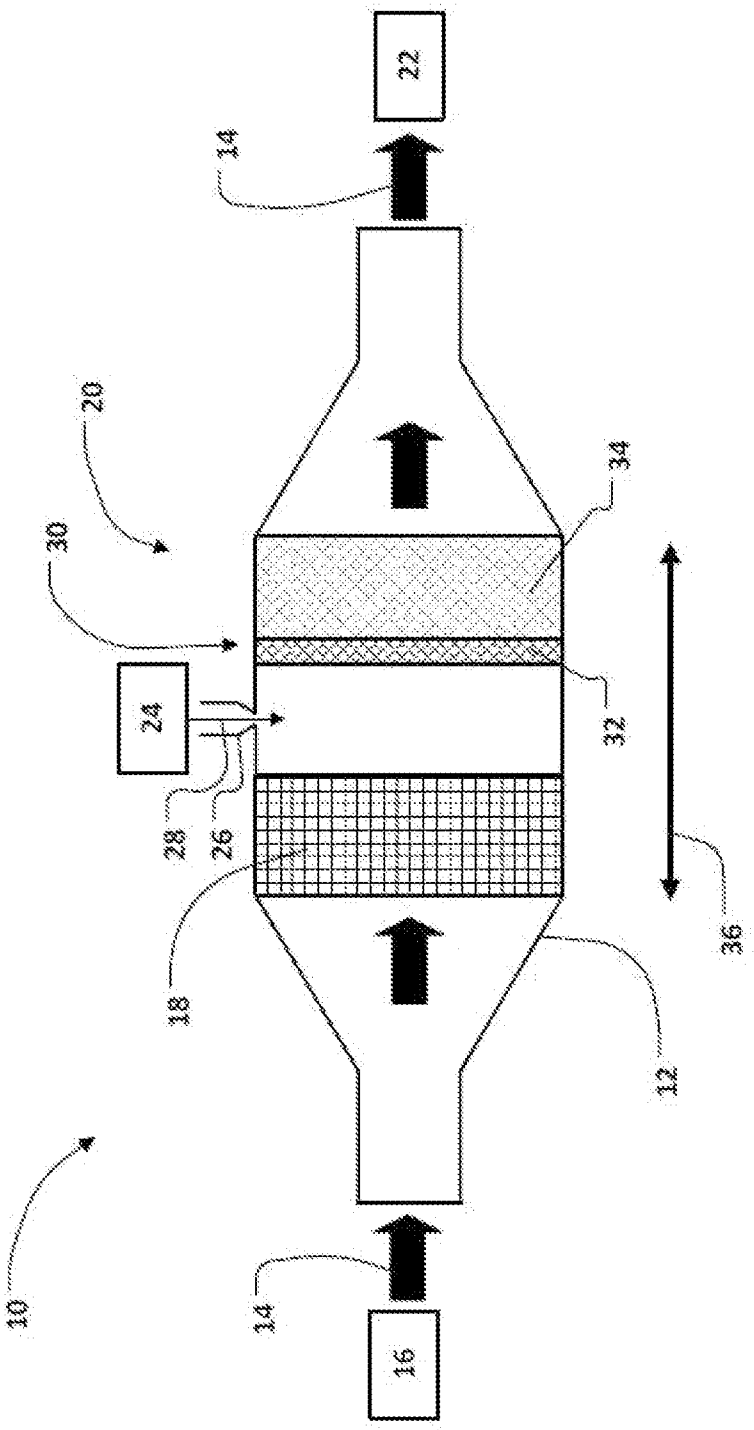


FIGURE 1

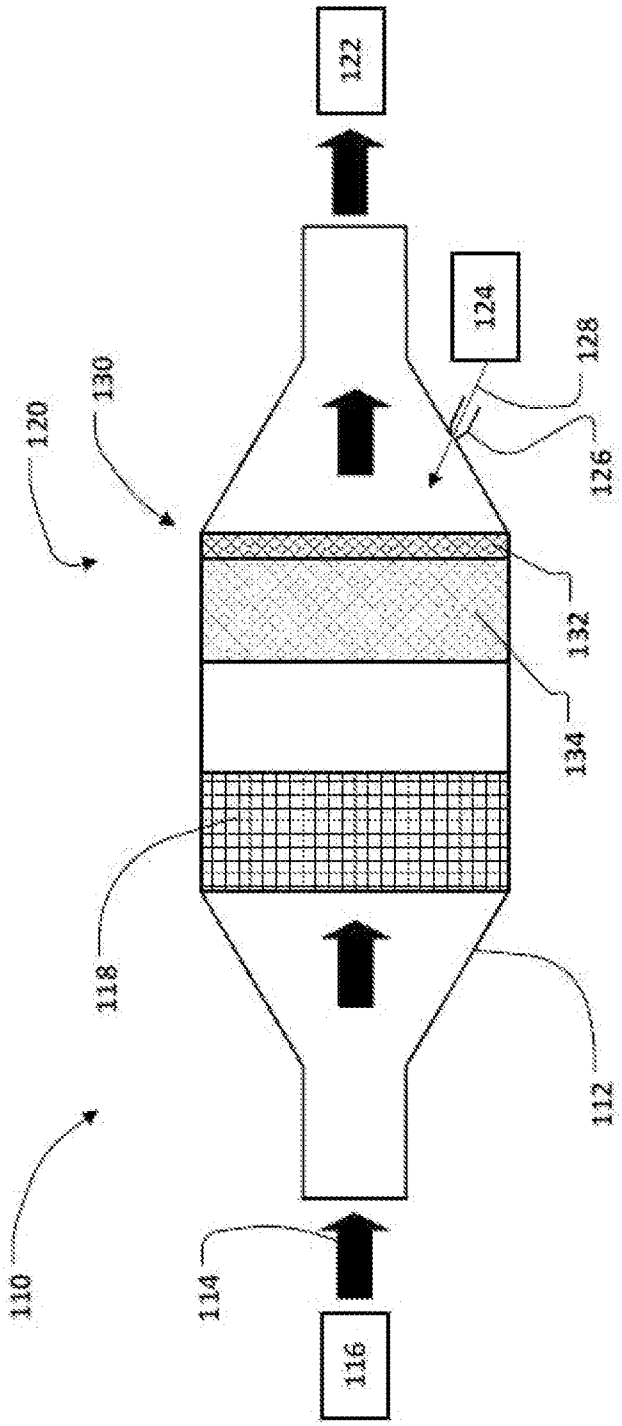


FIGURE 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/035033

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01N3/20 F01N3/035 B01D53/94 F01N13/00
ADD.

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)
F01N B01D

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C.

[X] 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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"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search	Date of mailing of the international search report
11 September 2015	21/09/2015

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	paragraphs [0033] - [0035], [0042] - [0046]; figures 1,2	5,15

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A	paragraphs [0030] - [0039]; figures 1,4,5	6,15

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