HYDROCARBON SCR AFTERTREATMENT SYSTEM

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ABSTRACT
An engine exhaust afltreatment system including a selective catalytic reduction (SCR) device. The system contains no significant amount of catalyzed material upstream of the SCR device.
HYDROCARBON SCR AFTERTREATMENT SYSTEM

TECHNICAL FIELD

[0001] The present disclosure relates to engine exhaust aftreatment systems, and more particularly to exhaust aftreatment systems employing NOx reduction technologies.

BACKGROUND

[0002] Systems may be included in an exhaust treatment or aftreatment system for a power system to remove or reduce nitrous oxide (NOx or NO) emissions coming from the exhaust of an engine. Two systems that may be used to reduce NOx are ammonia selective catalytic reduction (NH3-SCR) and hydrocarbon selective catalytic reduction (HC-SCR) systems. NH3 SCR systems use ammonia, commonly from urea, as a reductant while HC-SCR systems use hydrocarbon, commonly from fuel, as a reductant.

[0003] U.S. Patent Publication No. 2008/0155972 (the ’972 publn) describes multiple exhaust treatment systems. The ’972 publn discloses in FIG. 4a system including a filter having a catalyzed substrate upstream of an NH3-SCR and a clean-up catalyst.

SUMMARY

[0004] The present disclosure provides an engine exhaust aftreatment system including a selective catalytic reduction (SCR) device. In one aspect, the system includes no significant amount of catalyzed material upstream of the SCR device. In another aspect, the present disclosure provides a ratio of NO to NO2 exiting the engine that is substantially the same as a ratio of NO to NO2 entering the SCR device.

[0005] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a diagrammatic view of a power system including an engine and an exhaust aftreatment system.

DETAILED DESCRIPTION

[0007] As seen in FIG. 1, a power system 10 includes an engine 12, a fuel system 14, and an aftreatment system 16 to treat an exhaust stream 18 produced by the engine 12. The engine 12 may include other features not shown, such as controllers, air systems, cooling systems, peripheries, drivetrain components, turbochargers, exhaust gas recirculation systems, etc. The engine 12 may be any type of engine (internal combustion, gas, diesel, gaseous fuel, natural gas, propane, etc.), may be of any size, with any number of cylinders, and in any configuration (“V,” in-line, radial, etc.). The engine 12 may be used to power any machine or other device, including on-highway trucks or vehicles, off-highway trucks or machines, earth moving equipment, generators, aerospace applications, locomotive applications, marine applications, pumps, stationery equipment, or other engine powered applications.

[0008] The aftreatment system 16 includes a heat source 20, a diesel particulate filter (DPF) 22, a hydrocarbon selective catalytic reduction (HC-SCR) system 24, a clean-up catalyst 26, and an exhaust pipe 28. The exhaust stream 18 exits the engine 12, passes by the heat source 20, passes through the bare DPF 22, then passes through the HC-SCR system 24, and then passes through the clean-up catalyst 26 via the exhaust pipe 28.

[0009] The engine’s 12 fuel system 14 includes a fuel tank 30 holding fuel 32. The fuel 32 may be supplied to engine 12, heat source 20, and HC-SCR system 24 via fuel lines 34 and fuel pumps 36. In certain embodiments, the fuel system may have more than one fuel tank 30. More than one type of fuel 32 may also be used. The heat source 20 and HC-SCR system 24 may also not need to be supplied by fuel 32 in certain embodiments.

[0010] The heat source 20 regenerates the bare DPF 22. During operation, the bare DPF 22 collects particulate matter or soot. The heat source 20 heats the soot, typically in excess of 600 degrees Celsius, and burns it away.

[0011] The exhaust source 20 may include a housing 38 and a burner 40. The housing 38 may contain a flame 41 generated by the burner 40. The housing 38 may also route the exhaust stream 18 to be heated by the burner 40. The burner 40 may receive a supply of fuel 32 and may also include an ignition source and air supply to generate the flame 41. In alternative embodiments the heat source may not employ a fuel-fired burner 40. The heat source 20 may embody an electric heating element or microwave device. The heat source 20 may also embody operating the engine 12 under conditions to generate elevated exhaust stream 18 temperatures.

[0012] The bare DPF 22 removes particulate matter from the exhaust stream 18. The bare DPF 22 may be made from cordierite, silicon carbide, or other material to remove the particulate matter. The bare DPF 22 may be wall flow with a honeycomb cross-section. The bare DPF 22 contains no significant amount of catalyzed material.

[0013] The HC-SCR system 24 may include a reductant system 42, mixer 44, and a HC-SCR 46. The reductant system 42 is shown to include a valve 48 and injector 50. The fuel 32 may serve as a reductant for the HC-SCR 46 and the fuel tank 30 may serve as the reductant source. The reductant is driven from the fuel tank 30 via the pump 36 and delivery is controlled via the valve 48. In other embodiments, the reductant may be a different source of hydrocarbons than the fuel 32. The reductant source may also be different and separate from the engine’s 12 fuel system 14.

[0014] The injector 50 creates a reductant spray 52 or otherwise introduces the reductant or fuel 32 into the exhaust stream 18 or HC-SCR 46. The injector may or may not be air assisted. The mixer 44 may be added to aid mixing of the reductant with the exhaust stream 18.

[0015] The HC-SCR 46 includes a catalyst disposed on a substrate. The catalyst is configured to reduce an amount of NOx in the exhaust stream 18 by using a hydrocarbon as a reductant. One such HC-SCR uses silver tungstate as described in US Patent Application 2008/0069743.

[0016] The clean-up catalyst 26 may be included downstream of the HC-SCR 46. The clean-up catalyst 26 may be configured to capture, store, oxidize, reduce, and/or convert reductant that may slip past or breakthrough the HC-SCR 46. The clean-up catalyst may also convert carbon monoxide (CO) into carbon dioxide (CO2). The clean-up catalyst 26 may also reduce ammonia (NH3) that may be produced by the HC-SCR or otherwise present into nitrogen (N2). The clean-up catalyst may consist of an ammonia catalyst (AMox), diesel oxidation catalyst (DOC), NH3-SCR, or a combination of catalyst types. The clean-up catalyst 26 may also be a new
catalyst design configured to capture, store, oxidize, reduce, and/or convert the constituents present.

[0017] Controllers and sensors may also be added to the aftertreatment system 16. The sensors may measure parameters such as temperature, soot quantity, NOx level, etc. The controllers may receive data from the sensors and control the operation of the heat source 20, reductant system 42, and/or engine 12 to achieve a desired performance.

INDUSTRIAL APPLICABILITY

[0018] As described above, the disclosed aftertreatment system 16 does not contain a significant amount of catalyzed material upstream of the HC-SCR 46. The absent catalyzed material may represent an oxidation or other non-NOx reduction catalysts, such as a DOC. Removing the catalyzed material may enhance the operation of the aftertreatment system 16 as described below.

[0019] Avoiding a significant amount of catalyzed material or bodies upstream of the HC-SCR 46 may prevent sulfite poisoning that would deactivate the HC-SCR 46. A significant amount of catalyzed material may be the amount needed to generate a quantity of sulfates from the exhaust stream 18 that would deactivate the HC-SCR 46. Catalysts transform sulfur dioxide SO2 into sulfur trioxide SO3, which then becomes sulfuric acid via reaction with water (SO3 + H2O = H2SO4) or a sulfate (such as AgSO4) on the HC-SCR catalyst.

[0020] Applicants have found that the HC-SCR 46 is negatively impacted and deactivated from exposure to these sulfates. The negative impacts have even been experienced as a result of even small amounts of sulfates, such as levels generated by even ultra-low sulfur fuels. By removing the catalyzed bodies upstream of the HC-SCR 46, sulfite poisoning can be avoided.

[0021] Because the disclosed aftertreatment system 16 avoids catalyzed bodies upstream of the HC-SCR 46, heat source 20 is needed to regenerate the bare DPF 22. Other aftertreatment systems may use catalyzed bodies upstream or integrated with the DPF to achieve full or partial passive regeneration. Passive regeneration uses the catalyst to convert nitrogen monoxide (NO) into nitrogen dioxide (NO2). The NO2 is used by the DPF to oxidize the soot and regenerate the DPF at a lower temperature. The disclosed aftertreatment system 16, however, does not convert NO to NO2 upstream of the HC-SCR 46. Therefore, no substantial passive regeneration is achieved and heat source 20 may need to be capable of reaching high temperatures in a robust manner. This need for a heat source 20 capable of reaching high temperatures in a robust manner may be met through the use of a fuel fired burner 40.

[0022] In addition to achieving passive regeneration, other aftertreatment systems include catalyzed bodies upstream of the SCR to achieve a desired NO to NO2 ratio entering the SCR to improve the efficiency of the SCR. As mentioned above, in contrast to other SCR aftertreatment systems, the disclosed aftertreatment system 16 does not convert NO to NO2 upstream of the HC-SCR 46. In the disclosed aftertreatment system 16, the NO to NO2 ratio is substantially the same entering the HC-SCR 46 as it is exiting the engine 12. Applicants realized that the HC-SCR 46 is not sensitive to the NO to NO2 ratio like other SCR systems may be and therefore the catalyzed bodies upstream of the HC-SCR 46 are not needed to achieve this ratio.

[0023] The disclosed aftertreatment system 16 may also provide additional reductant to be used by the HC-SCR 46 in the form of engine out hydrocarbons and soluble organic fraction (SOF) long chain alkanes. The bare DPF 22 may store or trap SOF at low temperatures when the HC-SCR 46 is not active and release the SOF at higher temperatures when the HC-SCR 46 is active and the reductant is needed. This additional source of reductant may reduce the quantity needing to be supplied by the reductant system 42 and may reduce fuel consumption. In other aftertreatment systems, this additional source of reductant may be at least partially, consumed by the upstream catalyzed bodies.

[0024] Avoiding the catalyst bodies upstream of the HC-SCR 46 may also reduce backpressure in the aftertreatment system 16. Packaging of the aftertreatment system 16 may also be easier without the catalyzed body upstream of the HC-SCR 46.

[0025] Although the embodiments of this disclosure as described herein may be incorporated without departing from the scope of the following claims, it will be apparent to those skilled in the art that various modifications and variations can be made. Other embodiments will be apparent to those skilled in the art from consideration of the specification and practice of the disclosure. It is intended that the specification and examples be considered as exemplary only, with a true scope being indicated by the following claims and their equivalents.

What is claimed is:
1. An engine exhaust aftertreatment system comprising: a selective catalytic reduction (SCR) device in an exhaust stream of an engine, the SCR device including a composition that reduces an amount of NOx in the presence of a reductant; and wherein no significant amount of catalyzed material is present in the exhaust stream upstream of the SCR device.
2. The engine exhaust aftertreatment system of claim 1 wherein the SCR device is not sensitive to the ratio of NO to NO2 in the exhaust stream.
3. The engine exhaust aftertreatment system of claim 1 wherein the composition of the SCR device includes silver tungstate.
4. The engine exhaust aftertreatment system of claim 1 wherein the reductant is a hydrocarbon.
5. The engine exhaust aftertreatment system of claim 1 further including: a clean-up catalyst downstream of the SCR device.
6. The engine exhaust aftertreatment system of claim 1 further including: a diesel particulate filter present in the exhaust stream upstream of the SCR device.
7. The engine exhaust aftertreatment system of claim 1 further including: a heat source present in the exhaust stream upstream of the diesel particulate filter.
8. The engine exhaust aftertreatment system of claim 7 wherein the heat source is a fuel fired burner.
9. An engine exhaust aftertreatment system comprising: a selective catalytic reduction (SCR) device in an exhaust stream of an engine, the SCR device including a composition that reduces an amount of NOx in the presence of a reductant; and wherein a ratio of NO to NO2 exiting the engine is substantially the same as a ratio of NO to NO2 entering the SCR device.
10. The engine exhaust aftertreatment system of claim 9 wherein no significant amount of catalyzed material is present in the exhaust stream upstream of the SCR device.
11. The engine exhaust aftertreatment system of claim 9 wherein the SCR device is not sensitive to the ratio of NO to NO2 in the exhaust stream.

12. The engine exhaust aftertreatment system of claim 9 wherein the composition of the SCR device includes silver tungstate.

13. The engine exhaust aftertreatment system of claim 9 wherein the reductant is a hydrocarbon.

14. The engine exhaust aftertreatment system of claim 9 further including: a clean-up catalyst downstream of the SCR device.

15. The engine exhaust aftertreatment system of claim 9 further including: a diesel particulate filter present in the exhaust stream upstream of the SCR device.

16. The engine exhaust aftertreatment system of claim 15 further including: a heat source present in the exhaust stream upstream of the diesel particulate filter.

17. The engine exhaust aftertreatment system of claim 16 wherein the heat source is a fuel fired burner.