METHOD AND APPARATUS FOR GASEOUS MIXING IN A DIESEL EXHAUST SYSTEM

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ABSTRACT

A mixing device and method for a diesel exhaust system is disclosed having a chamber, a mixer within the chamber, and an injection tube supported on the mixer within the chamber. The mixer is positioned within the chamber adjacent an inlet and includes a plurality of angled blades to effect turbulent flow in a diesel exhaust stream entering the chamber through the inlet. The injection tube includes a plurality of injection points (e.g., openings) for discharging a reagent, such as gaseous ammonia (NH₃), into the exhaust stream. The injection tube is curved, and more specifically it is coiled with the injection points spread along the length of the tube in order to deliver reagent across a section of the chamber perpendicular to the exhaust stream flow.
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TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to an apparatus and method for treating and mixing diesel exhaust in a diesel exhaust system. Particularly, the present invention provides methods and apparatus for injecting reagent into a diesel exhaust stream to reduce nitrogen oxides (NOx) without increasing the packing space of the exhaust system.

BACKGROUND OF THE INVENTION

[0002] Diesel engines are efficient, durable and economical. Diesel exhaust, however, can harm both the environment and people. To reduce this harm, governments, such as the United States and the European Union, have proposed stricter diesel exhaust emission regulations. These environmental regulations require diesel engines to meet the same pollution emission standards as gasoline engines.

[0003] Typically, to meet such regulations and standards, systems require equipment additions and modifications. Additional equipment can often lead to additional weight and/or additional packaging length.

[0004] For example, a lean burning engine provides improved fuel efficiency by operating with an amount of oxygen in excess of the amount necessary for complete combustion of the fuel. Such engines are said to run “lean” or on a “lean mixture.” However, the increase in fuel efficiency is offset by the creation of undesirable pollution emissions in the form of nitrogen oxides (NOx). One method used to reduce NOx emissions from lean burn internal combustion engines is known as selective catalytic reduction. When used to reduce NOx emissions from a diesel engine, selective catalytic reduction involves injecting atomized urea into the exhaust stream of the engine in relation to one or more selected engine operational parameters and running the stream through a reactor containing a catalyst. However, selective catalytic reduction and the use of aqueous urea involve many disadvantages, including added packaging weight and added packaging length to the exhaust system, as well as the highly corrosiveness and poor lubricity of aqueous urea.

[0005] It would be advantageous to provide methods and apparatus for addressing the regulations and standards without adding weight or length to an already complex diesel exhaust system. Accordingly, it would be advantageous to provide methods and apparatus for injecting a NOx reducing reagent into the diesel exhaust stream of a lean burn engine where little or no added weight or packaging length is required. Further, it would be advantageous to provide a mixing system which creates a more homogenous mixture in a limited length. It would also be advantageous to provide an injector which is capable of distributing the reagent more uniformly throughout a cross-section of the treatment area. Accordingly, it would be advantageous to provide multiple injection points within a diesel exhaust stream.

[0006] The methods and apparatus of the present invention provide the foregoing and other advantages.

SUMMARY OF THE INVENTION

[0007] There is disclosed herein an improved diesel exhaust treatment system and method which avoid disadvantages of prior devices and methods, while affording additional structural and operating advantages.

[0008] Generally speaking, a mixing device for a diesel exhaust system is disclosed having a chamber, a mixer within the chamber, and an injection tube supported on the mixer within the chamber. The mixer is positioned within the chamber adjacent an inlet and includes a plurality of angled blades to effect turbulent flow in a diesel exhaust stream entering the chamber through the inlet.

[0009] In specific embodiments of the system, the injection tube includes a plurality of injection points (e.g., openings) for discharging a reagent into the exhaust stream. The injection tube is curved, and more specifically it is coiled with the injection points spread along the length of the tube in order to deliver reagent across a section of the chamber perpendicular to the exhaust stream flow.

[0010] The disclosed method for mixing gaseous ammonia in a diesel exhaust system begins with a diesel exhaust stream from a diesel engine passing from the engine through a conduit in fluid communication with the engine. The exhaust stream is directed to flow through the conduit into a housing having a mixer, an injection tube and an exit disposed therein. Turbulent flow in the diesel exhaust stream is created within the housing as the stream passes through the mixer. A continuous injection of gaseous NH3 from the injection tube into the diesel exhaust stream is made as the stream moves from the mixer toward the housing exit to create a treated homogenous exhaust stream. Finally, the treated exhaust stream is discharged through the housing exit.

[0011] These and other aspects of the invention may be understood more readily from the following description and the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] For the purpose of facilitating an understanding of the subject matter sought to be protected, there are illustrated in the accompanying drawings embodiments thereof, from an inspection of which, when considered in connection with the following description, the subject matter sought to be protected, its construction and operation, and many of its advantages should be readily understood and appreciated.

[0013] FIG. 1 is a schematic illustrating a typical mixer/injector device in a diesel exhaust system;

[0014] FIG. 2 is a schematic illustrating an embodiment of a mixer/NH3 injection device of the present invention in a diesel exhaust system;

[0015] FIG. 3 is a schematic illustrating another embodiment of a mixer/NH3 injection device of the present invention in a diesel exhaust system;

[0016] FIG. 4 is a front view of an embodiment of a mixer/ NH3 injection device; and

[0017] FIG. 5 is a perspective view of the mixer/NH3 injection device of FIG. 4.

DETAILED DESCRIPTION OF THE INVENTION

[0018] While this invention is susceptible of embodiments in many different forms, there is shown in the drawings and will herein be described in detail a preferred embodiment of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspect of the invention to embodiments illustrated.
Referring to FIG. 1, there is illustrated a typical mixer/injector device. Exhaust is discharged from the diesel engine 100, through conduit such as exhaust piping to an exhaust treatment system 110. The exhaust treatment system 110 typically consists of, in downstream order, a diesel oxidation catalyst (DOC) 112, a diesel particulate filter (DPF) 114, a mixer/NH₃ treatment canister 116, and a NOₓ slip catalyst (NSC) 118. The DOC 112, DPF 114 and NSC 118 are additional exhaust treatment structures present in most diesel exhaust treatment systems and which form no part of the present system 10. Such structures will be generally referenced herein and identified in the drawing figures but, as each of these additional exhaust treatment structures is commonly understood by those skilled in the art, a detailed discussion of each is avoided for the purpose of focusing discussion on the system 10 as set forth in the appended claims.

The mixer/treatment canister 116 is shown to include a connection pipe 120 with an injector 122 at the upstream end where NH₃—or an NH₃ containing reagent—is injected into a laminar diesel exhaust flow as it is discharged from the DOC 112 and DPF 114. The ammonia/exhaust stream then passes through a mixer 124 to effect mixing of the NH₃ and the diesel exhaust. A substantial length of pipe 120 is needed to allow for adequate mixing of the two components before the flow enters the NSC 118. As such, the mixer/injector system adds packaging length and weight to the diesel exhaust system 100 which might otherwise be used for other after-treatment substrates.

Referring to FIGS. 2-5, there is illustrated a mixer/ 
NH₃ injection system, generally designated by the numeral 10. The system 10 is shown in two distinct exhaust treatment configurations. FIG. 2 illustrates a configuration similar to that of FIG. 1 where the downstream order of components is DOC 12, then DPF 14 and NSC 18 sandwiched about system 10. Alternatively, FIG. 3 illustrates a configuration where the 
NSC 18 is on the DPF 14—in i.e., NOₓ slip catalyst on diesel particulate filter (NPF) 19—sandwiching the system 10 with the DOC 12. Other configurations may exist in which the system 10 is moved up or downstream in the exhaust flow.

Regardless of the specific configuration, it is clear from examination of FIGS. 2 and 3 that the packaging space required for system 10 is substantially reduced from that required for a typical mixer/injector device 110 illustrated in FIG. 1.

Generally speaking, system 10 is comprised of a housing 20 defining a mixing chamber 25, an injection tube 22 fed by an exterior injector boss 30 coupled to a supply (not shown), and a mixer 24. FIGS. 2 and 3 illustrate the diameter of the housing 20 (approx. 12 inches (30.5 cm)) is substantially equal to that of the surrounding structures—e.g., DPF 14 and NSC 18. By providing the larger diameter system housing 20 (vs. narrow connecting pipe 120), the need for reducers 123 (FIG. 1) is eliminated, further reducing the packaging size of the entire diesel exhaust treatment system.

FIGS. 4 and 5 illustrate a specific embodiment of a single-plane, coiled injection tube 22. Injection tube 22 enters through the housing sidewall and begins a tortuous path to a center of the chamber 25. The tube 22 includes a series of injection points 23 where reagent can be emitted into the chamber 25. The injection points 23 are spaced along the tube 22 and, therefore, throughout a cross-section of the chamber 25 to provide a more uniform distribution of reagent throughout that cross-section of the mixing chamber 25. The uniform distribution into the exhaust stream results in a more homogeneous mixture of reagent and exhaust in a shorter mixing period.

The tube 22 may be configured in several alternative shapes, including circular and serpentine, so long as a distribution of the injection points 23 throughout a cross-section of the chamber is provided. Further, the injection points 23 comprise small openings in the tube 22 to allow discharge of the reagent from the tube 22. To effect a uniform or even discharge from all the injection points 23, the first opening has a very small diameter and successive opening diameters increase toward the tube end 27—in i.e., the smallest diameter openings are positioned at the beginning of the tube where the fluid pressure is the greatest. The purpose, again, is to achieve even distribution of reagent across the entire cross-section of the mixing chamber 25.

Also shown in FIGS. 4 and 5, is exhaust flow mixer 24. The mixer 24 is comprised of a plurality of fixed blades 37, four are shown, secured to one another at a midpoint and outwardly to and within a short section (approx. six inches (15.2 cm)) of the housing 20. The blades 37 are angled from back to front as a way of imparting a turbulent flow to the substantially laminar exhaust flowing system 10. Though not shown, additional blade configurations are possible to achieve the desired turbulent exhaust flow for mixing.

Another feature of the mixer 24 is that it supports the injection tube 22. That is, the tube 22, which is positioned on the downstream side of the mixer 24, attaches to, by way of welds or any other suitable attachment means, each of the mixer blades 37 for simple structural support. Attachment may be achieved, for example, at the areas 39 where the tube 22 crosses each blade 37. The securing of the coiled tube 22 alleviates damage which might otherwise be caused by the more violent vibration of the tube 22 during operation of the vehicle. Reagent (e.g., gaseous NH₃) discharged from injection points 23 immediately enters the turbulent diesel exhaust stream as it moves toward the chamber exit 35 (FIGS. 2 and 3). A relatively short distance is needed to provide the necessary mixing time to create a homogeneous reagent/diesel exhaust.

The homogenous mixture is then exited from the mixing chamber 25 into one of either the NSC 18 (FIG. 2) or the NPF 19 (FIG. 3) for further treatment.

The matter set forth in the foregoing description and accompanying drawings is offered by way of illustration only and not as a limitation. While particular embodiments have been shown and described, it will be apparent to those skilled in the art that changes and modifications may be made without departing from the broader aspects of applicants' contribution. The actual scope of the protection sought is intended to be defined in the following claims when viewed in their proper perspective based on the prior art.

What is claimed is:

1. A mixing device for a diesel exhaust system comprising:
   a chamber having an inlet at one end for permitting entrance of an exhaust stream from a diesel engine and an outlet at an opposing end;
   a mixer within the chamber adjacent the inlet and positioned to effect turbulent flow in an exhaust stream entering the chamber through the inlet; and
   an injection tube supported within the chamber by the mixer.
2. The mixing device of claim 1, wherein the injection tube comprises a plurality of injection points therein for discharging a reagent into the exhaust stream, and extends within a plane of the chamber.

3. The mixing device of claim 2, wherein the injection tube is curved.

4. The mixing device of claim 2, wherein the injection tube is coiled.

5. The mixing device of claim 1, wherein the mixer comprises a plurality of fixed blades angled to deflect the exhaust stream.

6. The mixing device of claim 2, wherein the mixer comprises a plurality of blades angled to impart mixing to the exhaust stream and the injection tube extends across each blade within the chamber.

7. The mixing device of claim 1, wherein the injection tube is connected to the mixer.

8. The mixing device of claim 1, wherein the chamber is positioned between a diesel particulate filter (DPF) and a NOx slip catalyst canister.

9. The mixing device of claim 1, wherein the chamber is positioned between a diesel oxidation catalyst (DOC) canister and a NOx particulate filter (NPF) canister.

10. A mixing device for a diesel exhaust system comprising:

a. a chamber having an inlet at one end for permitting entrance of an exhaust stream from a diesel engine and an outlet at an opposing end;

b. a mixer within the chamber adjacent the inlet, and an injection tube having a plurality of injection points and extending into the chamber.

11. The mixing device of claim 10, wherein the injection tube is supported by the mixer within the chamber.

12. The mixing device of claim 10, wherein the injection tube is curved.

13. The mixing device of claim 12, wherein the injection tube is coiled.

14. The mixing device of claim 10, wherein the mixer comprises a plurality of fixed blades angled to effect turbulent flow in the exhaust stream.

15. The mixing device of claim 11, wherein the mixer comprises a plurality of blades angled to impart mixing to the exhaust stream and the injection tube extends across each blade within the chamber.

16. The mixing device of claim 10, wherein the injection tube is connected to the mixer.

17. The mixing device of claim 10, wherein the chamber is positioned between a diesel particulate filter (DPF) and a NOx slip catalyst canister.

18. The mixing device of claim 10, wherein the chamber is positioned between a diesel oxidation catalyst (DOC) canister and a NOx particulate filter (NPF) canister.

19. A method for mixing gaseous ammonia in a diesel exhaust system comprising the steps of:

a. exhausting a diesel exhaust stream from an engine through a conduit in fluid communication with the engine;

b. directing the diesel exhaust stream to flow through the conduit into a housing having a mixer, an injection tube and an exit disposed therein;

c. creating a turbulent flow in the diesel exhaust stream within the housing as the stream passes through the mixer;

d. injecting gaseous NH₃ from the injection tube into the diesel exhaust stream as the stream moves from the mixer toward the housing exit to create a treated exhaust stream; and

e. discharging the treated exhaust stream through the housing exit.

20. The method of claim 19, wherein the mixer comprises a plurality of fixed blades angled to deflect the diesel exhaust stream.

21. The method of claim 19, wherein the injection tube comprises a plurality of injection points for introducing NH₃ gas into the diesel exhaust stream.

22. The method of claim 21, wherein the injection tube is supported in the housing by the mixer.

23. The method of claim 21, wherein the injection tube comprises a coil.

24. The method of claim 19, further comprising the step of creating a homogenous mixture of diesel exhaust and gaseous NH₃.

25. The method of claim 24, wherein the step of creating a homogenous mixture comprises the step of injecting gaseous NH₃ into the diesel exhaust stream at a plurality of points.

26. The method of claim 25, wherein the injection tube comprises a plurality of injection points spaced throughout a cross-section of the housing.

27. A method of treating diesel exhaust from an engine in a motor vehicle, the method comprising the steps of:

a. exhausting a diesel exhaust stream from an engine through a conduit in fluid communication with the engine;

b. directing the diesel exhaust stream to flow through the conduit into a housing having a mixer, an injection tube and an exit disposed therein, wherein the injection tube is in fluid communication with a reagent supply;

c. creating a turbulent flow in the diesel exhaust stream within the housing as the stream passes through the mixer;

d. injecting a gaseous reagent from the reagent supply through the injection tube into the diesel exhaust stream as the stream moves from the mixer toward the housing exit to create a treated exhaust stream; and

e. discharging the treated exhaust stream through the housing exit.

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