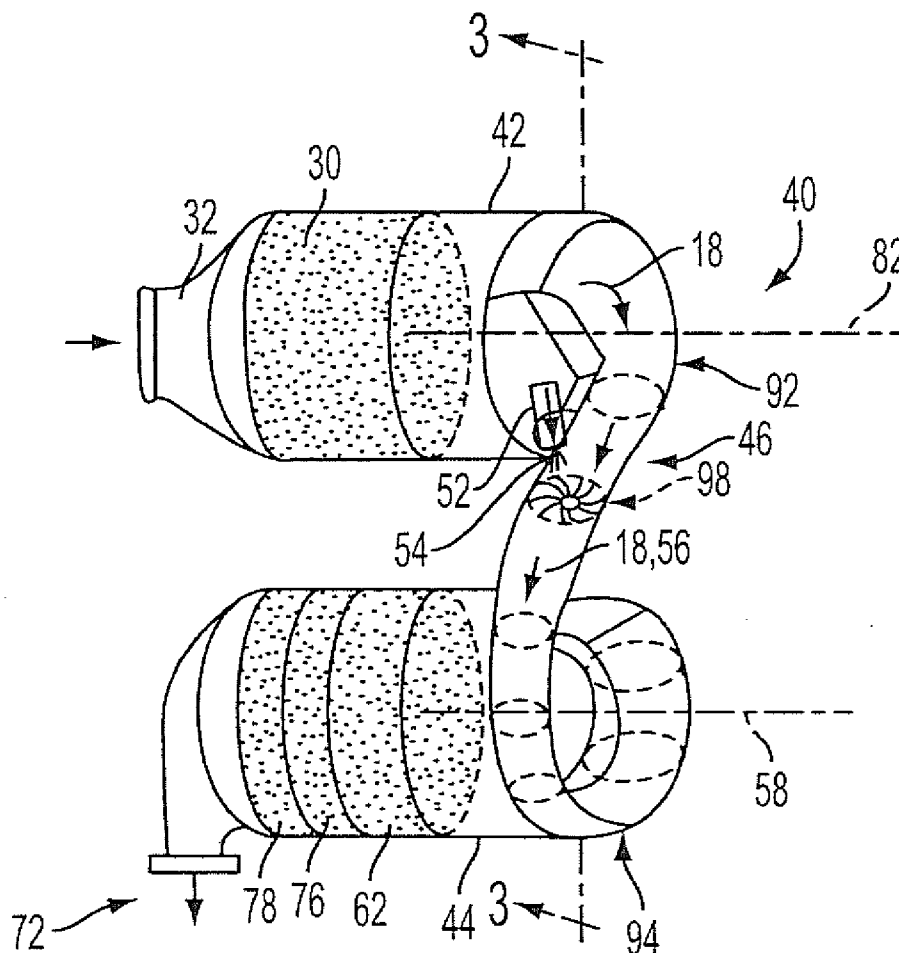




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Li et al.(10) **Pub. No.: US 2015/0308316 A1**(43) **Pub. Date: Oct. 29, 2015**(54) **INTEGRATED MIXING SYSTEM FOR
EXHAUST AFTERTREATMENT SYSTEM****Publication Classification**(71) Applicant: **GM GLOBAL TECHNOLOGY
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OPERATIONS LLC**, Detroit, MI (US)(57) **ABSTRACT**

In one aspect, a swirl can mixer assembly for mixing a fluid with exhaust gas exhausted from an internal combustion engine is provided. The assembly includes an inlet portion including an injection area configured to receive a fluid injector for dispensing the fluid into the exhaust gas for mixing with the exhaust gas in the mixing assembly to produce an exhaust gas/fluid mixture, an outlet portion, and an extended mixing conduit fluidly coupled between the inlet portion and the outlet portion. The extended mixing conduit is curved about at least a portion of a circumference of the outlet portion to induce a swirl in the exhaust gas/fluid mixture such that the exhaust gas/fluid mixture enters the outlet portion tangentially thereto.

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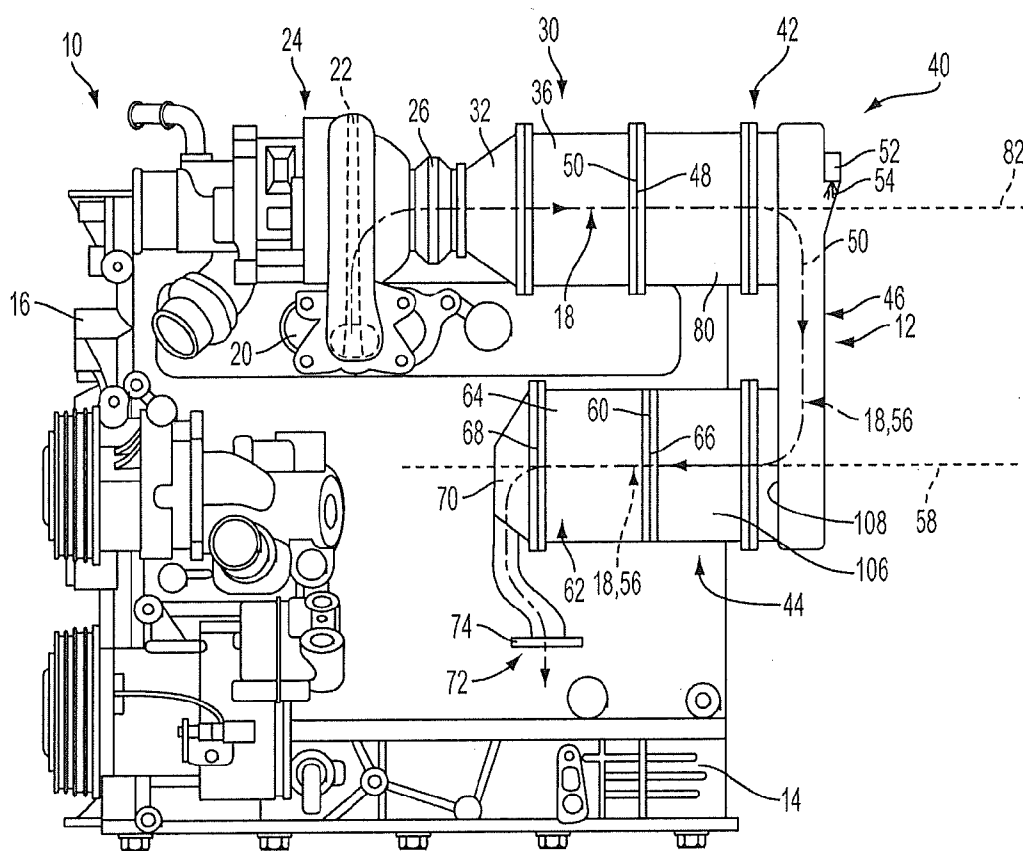


FIG. 1

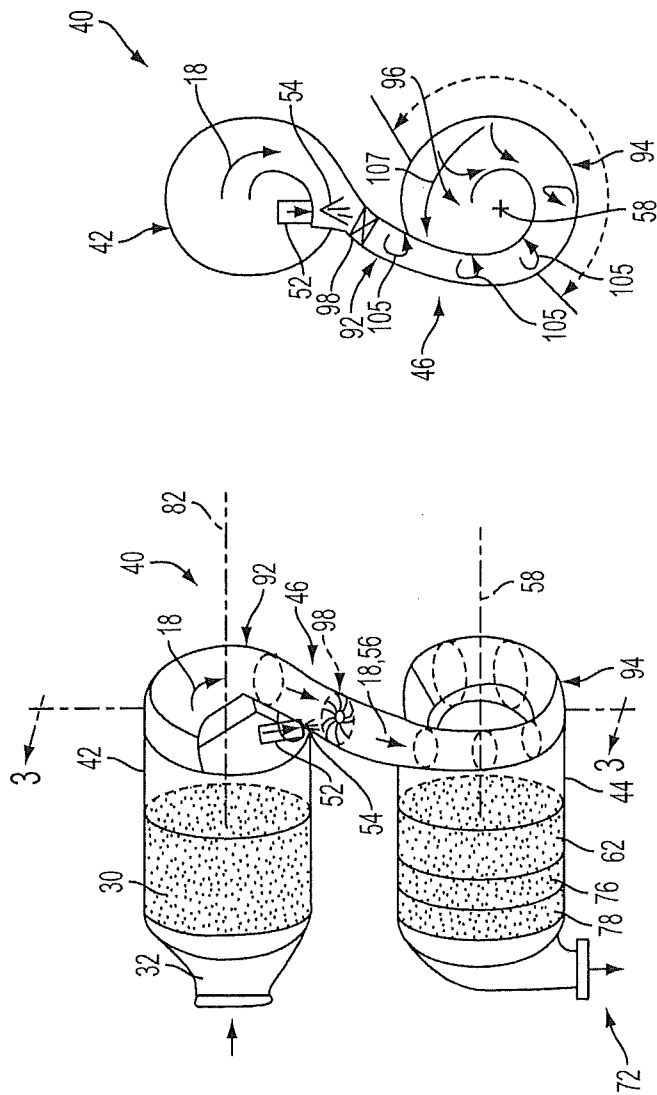


FIG. 2

FIG. 3

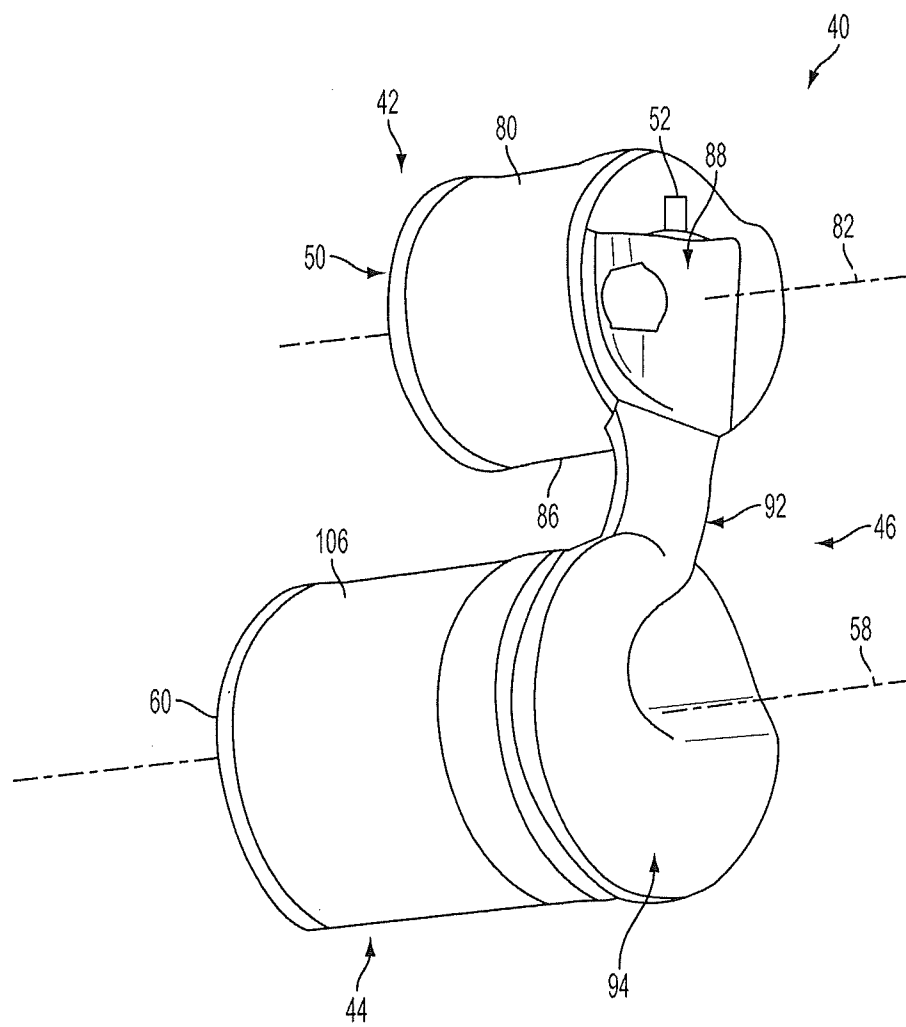
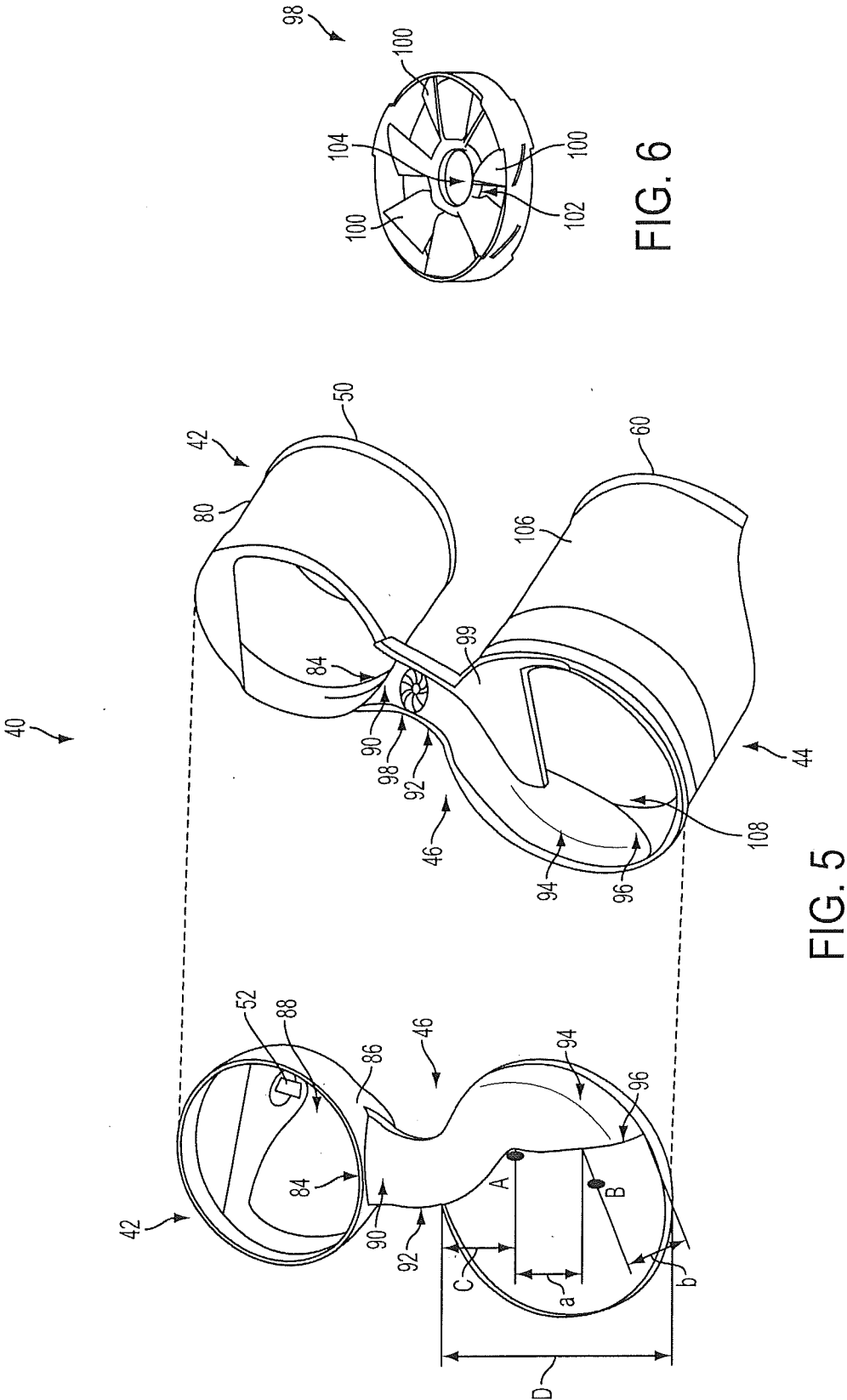


FIG. 4



INTEGRATED MIXING SYSTEM FOR EXHAUST AFTERTREATMENT SYSTEM

FIELD OF THE INVENTION

[0001] Exemplary embodiments of the invention relate to exhaust treatment systems for internal combustion engines and, more particularly, to exhaust treatment systems that fully mix fluids injected into an exhaust gas flow in a short physical length.

BACKGROUND

[0002] The exhaust gas emitted to an exhaust treatment system from an internal combustion engine is a heterogeneous mixture that contains gaseous emissions such as carbon monoxide ("CO"), unburned hydrocarbons ("HC") and oxides of nitrogen ("NO_x") as well as condensed phase materials (liquids and solids) that constitute particulate matter. Catalyst compositions, typically disposed on catalyst supports or substrates, are provided in various exhaust system devices to convert certain, or all of these exhaust constituents into non-regulated exhaust gas components.

[0003] An exhaust treatment technology in use for high levels of particulate matter reduction, particularly in diesel engines, is the Particulate Filter ("PF") device. There are several known filter structures used in PF devices that have displayed effectiveness in removing the particulate matter from the exhaust gas such as ceramic honeycomb wall flow filters, wound or packed fiber filters, open cell foams, sintered metal fibers, etc. Ceramic wall flow filters have experienced significant acceptance in automotive applications.

[0004] The filter in a PF device is a physical structure for removing particulates from exhaust gas and, as a result, the accumulation of filtered particulates will have the effect of increasing the exhaust system backpressure experienced by the engine. To address backpressure increases caused by the accumulation of exhaust gas particulates, the PF device is periodically cleaned, or regenerated. The regeneration operation burns off the carbon and particulate matter collected in the filter substrate and regenerates the PF device.

[0005] Regeneration of a PF device in vehicle applications is typically automatic and is controlled by an engine or other controller based on signals generated by engine and exhaust system sensors such as temperature sensors and back pressure sensors. The regeneration event involves increasing the temperature of the PF device to levels that are often above 600 C in order to burn the accumulated particulates.

[0006] One method of generating the temperatures required in the exhaust system for regeneration of the PF device is to deliver unburned HC (often in the form of raw fuel) to an oxidation catalyst ("OC") device disposed upstream of the PF device. The HC may be delivered by injecting fuel (either as a liquid or pre-vaporized) directly into the exhaust gas using an HC injector/vaporizer. The HC is oxidized in the OC device resulting in an exothermic reaction that raises the temperature of the exhaust gas. The heated exhaust gas travels downstream to the PF device to thereby burn (oxidize) the particulate accumulation.

[0007] A challenge for designers, especially those involved in space limited automotive applications, is that injecting fluids such as HC into the exhaust gas upstream of an OC device, or any other device for that matter, must allow for sufficient residence time, turbulence and distance in the exhaust flow for the injected fluid to become sufficiently

mixed with and vaporized in the exhaust gas prior to entering the device. Without proper preparation, the injected fluid will not properly oxidize in the OC device and some unburned HC may pass through the device. The result is wasted fuel passing through the exhaust treatment system and uneven temperatures within the devices.

[0008] A technology that has been developed to reduce the levels of NO_x emissions in lean-burn engines (ex. diesel engines) that burn fuel in excess oxygen includes a Selective Catalytic Reduction ("SCR") device. An SCR catalyst composition disposed in the SCR device preferably contains a zeolite and one or more base metal components such as iron ("Fe"), cobalt ("Co"), copper ("Cu") or vanadium ("V") which can operate efficiently to reduce NO_x constituents in the exhaust gas in the presence of a reductant such as ammonia ("NH₃"). The SCR catalyst may be applied as a wash coat to either a conventional flow-through substrate or on the substrate of a particulate filter. The reductant is typically delivered as a liquid upstream of the SCR device, in a manner similar to the HC discussed above, and travels downstream to the SCR device to interact with the SCR catalyst composition; reducing the levels of NO_x in the exhaust gas passing through the SCR device. Like the HC discussed above, without proper mixing and evaporation, the injected reductant, urea or ammonia for instance, will not properly function in the SCR device and some of the fluid may pass through the device resulting in wasted reductant as well as reduced NO_x conversion efficiency.

[0009] Typical exhaust treatment systems may include several exhaust treatment devices as described above. In many instances, whether historical or not, the devices may comprise individual components that are serially disposed along an exhaust conduit that extends from the exhaust manifold outlet of the internal combustion engine to the tailpipe outlet of the exhaust treatment system. To meet more stringent exhaust emission requirements, the exhaust treatment devices may need to be lighted-off as quickly as possible in emission cycles. As such, it is desirable to locate the exhaust treatment devices as close to the engine as possible, for example, close-coupled with turbochargers or exhaust manifolds. As vehicle architectures become smaller and demand close-coupled position designs, the desired length for an exhaust treatment system may not necessarily be available.

[0010] Accordingly it is desirable to provide a system that will achieve uniform mixing and distribution of a fluid injected into the exhaust gas in an exhaust treatment system in a compact distance.

SUMMARY

[0011] In one aspect, a swirl can mixer assembly for mixing a fluid with exhaust gas exhausted from an internal combustion engine is provided. The assembly includes an inlet portion including an injection area configured to receive a fluid injector for dispensing the fluid into the exhaust gas for mixing with the exhaust gas in the mixing assembly to produce an exhaust gas/fluid mixture, an outlet portion, and an extended mixing conduit fluidly coupled between the inlet portion and the outlet portion. The extended mixing conduit is curved about at least a portion of a circumference of the outlet portion to induce a swirl in the exhaust gas/fluid mixture such that the exhaust gas/fluid mixture enters the outlet portion tangentially thereto.

[0012] In another aspect, an exhaust gas treatment system configured to receive exhaust gas from an internal combustion

tion engine is provided. The system includes a catalyst device and a swirl can mixer assembly for mixing a fluid with the exhaust gas. The swirl can mixer assembly includes an inlet portion including an injection area and a fluid injector coupled to the inlet portion and configured to dispense the fluid into the exhaust gas in the injection area for mixing with the exhaust gas in the mixing assembly to produce an exhaust gas/fluid mixture. The assembly further includes an outlet portion coupled to the catalyst device and an extended mixing conduit fluidly coupled between the inlet portion and the outlet portion. The extended mixing conduit is curved about at least a portion of a circumference of the outlet portion to induce a swirl in the exhaust gas/fluid mixture such that the exhaust gas/fluid mixture enters the outlet portion tangentially thereto.

[0013] The above features and advantages and other features and advantages of the invention are readily apparent from the following detailed description when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Other objects, features, advantages and details appear, by way of example only, in the following detailed description of embodiments, the detailed description referring to the drawings in which:

[0015] FIG. 1 is a schematic view of an internal combustion engine and associated exhaust treatment system embodying features of the invention;

[0016] FIG. 2 is a perspective view of a compact mixing assembly shown in FIG. 1 and illustrating fluid flow there-through;

[0017] FIG. 3 is a cross-sectional view of the compact mixing assembly shown in FIG. 2 and taken along line 3-3;

[0018] FIG. 4 is a perspective view of the compact mixing assembly shown in FIG. 1;

[0019] FIG. 5 is a cut-away view of the compact mixing assembly shown in FIG. 4; and

[0020] FIG. 6 is a perspective view of an exemplary mixer device that may be used with the compact mixing assembly shown in FIGS. 1-5.

DESCRIPTION OF THE EMBODIMENTS

[0021] The following description is merely exemplary in nature and is not intended to limit the present disclosure, its application or uses. It should be understood that throughout the drawings corresponding reference numerals indicate like or corresponding parts and features.

[0022] Referring to FIG. 1, an internal combustion engine 10 is illustrated. It should be noted that the invention disclosed herein has application to any type of internal combustion engine requiring an exhaust treatment system in which a fluid such as hydrocarbon ("HC") or urea (or other ammonia ("NH₃")) containing fluid or gas is injected. In the description below, a diesel engine 10 and associated exhaust treatment system 12 is described. The diesel engine comprises a cylinder block 14 and a cylinder head 16 which, when combined, define piston cylinders and combustion chambers (not shown). Reciprocating pistons (not shown) are disposed in the piston cylinders and are operable to compress air which combusts when compressed and mixed with an injected fuel in a manner well known in the art. Products of combustion, or exhaust gas 18, exits the cylinder head 16 through exhaust port 20 (which may be associated with an exhaust manifold

(not shown)) that, in the exemplary embodiment shown, leads to the exhaust turbine side 22 of an exhaust driven turbocharger 24. The exhaust gas spins an impeller (not shown) which is rotatably mounted within the exhaust turbine side of the turbocharger and subsequently exits the turbocharger through an exit port 26. The exit port is in fluid communication with the exhaust treatment system 12 and exhaust gas 18 departing the turbocharger 24 through the exit port 26 is transferred thereto.

[0023] The exhaust treatment system 12 may comprise one of many configurations depending upon the particular application of the engine 10 and its installation (i.e. vehicle, stationary etc.). In the configuration shown in FIG. 1, exhaust gas 18 exiting the exhaust driven turbocharger 24 enters an oxidation catalyst ("OC") device 30 through an inlet cone 32 that is in fluid communication with the exit port 26. The OC device 30 may include, for example, a flow-through metal or ceramic monolith substrate (not shown) that is packaged in a stainless steel shell or canister 36 having an inlet and an outlet in fluid communication with the exhaust gas 18 in the exhaust treatment system 12. The substrate typically may include an oxidation catalyst compound disposed thereon. The oxidation catalyst compound may be applied as a wash coat and may contain platinum group metals such as platinum ("Pt"), palladium ("Pd"), rhodium ("Rh") or other suitable oxidizing catalysts, or combinations thereof. The OC device 30 is useful in treating unburned gaseous and non-volatile HC and CO, which are oxidized to form carbon dioxide and water.

[0024] In the exemplary embodiment, a compact mixing assembly or swirl can mixer assembly 40 is located immediately downstream of the OC device 30 and is configured to receive exhaust gas exiting the OC device 30. Swirl can mixer 40 includes an inlet portion 42, an outlet portion 44, and an extended mixing conduit 46 extending therebetween. In the illustrated exemplary embodiment, an outlet 48 of the OC device and an inlet 50 of the swirl can inlet portion 42 are configured with similar diameters to thereby provide a leak-free seal thereabout while imposing little or no restriction upon the flow of exhaust gas 18.

[0025] A reductant fluid injector 52 is mounted to swirl can mixer inlet portion 42 upstream of the extended mixing conduit 46 and injects an ammonia ("NH₃") based reductant 54 (e.g., FIGS. 2 and 3) into the flow of the exhaust gas 18 as it enters the extended mixing conduit 46. The swirl can mixer 40 operates to vaporize the reductant 54 and to mix it with the exhaust gas 18 in a manner that is described herein in more detail.

[0026] The reductant 54 is mixed with the exhaust gas 18 in the swirl can mixer 40 to form an exhaust gas/reductant mixture 56, and swirl can mixer 40 induces a swirling action of mixture 56 that is tangential to or swirls about an axis 58 of the mixer outlet portion 44. The swirl induced mixture 56 subsequently departs through a mixer outlet 60 and may be transported to a Selective Catalytic Reduction ("SCR") device 62 disposed below and in parallel alignment with the OC device 30. Similarly, the mixer outlet portion 44 is disposed below and in parallel alignment with the mixer inlet portion 42.

[0027] The SCR device 62 may include, for example, a flow-through metal or ceramic monolith substrate that is packaged in a stainless steel shell or canister 64 having an inlet 66 and an outlet 68 in fluid communication with the exhaust gas/reductant mixture 56 in the swirl can mixer 40. An SCR catalyst composition disposed in the SCR device 62

preferably contains a zeolite and one or more base metal components such as iron ("Fe"), cobalt ("Co"), copper ("Cu") or vanadium ("V") which can operate efficiently to reduce NO_x constituents in the exhaust gas 18 in the presence of the ammonia ("NH₃") based reductant. The outlet 68 of the SCR device 62 may comprise an exhaust gas collector such as exit cone 70 having an outlet 72 configured with a flange member 74 that allows the exhaust treatment system 12 to be fluidly connected to an exhaust gas conduit (not shown) that will conduct the exhaust gas to additional exhaust treatment devices (if installed) and subsequently to the atmosphere.

[0028] In the exemplary embodiment, the swirl can outlet portion 44 and the SCR inlet 66 are configured with similar diameters to thereby provide a leak-free seal thereabout while imposing little or no restriction upon the flow of mixture 56. As illustrated in FIG. 2, canister 64 may also include a second OC device 76 and a particulate filter ("PF") device 78. However, canister 64 may include only one of the SCR device 62, the OC device 76, and the PF device 78, or may include any combination thereof. The exhaust gas 18 may be mixed with a hydrocarbon ("HC") (not shown) and oxidized in the second OC device 76 resulting in an exothermic reaction that raises the temperature of the exhaust gas. The heated exhaust gas travels downstream to PF device 78 to thereby burn (oxidize) particulate accumulation in a known manner.

[0029] Referring to FIGS. 2-5, an exemplary swirl can mixer 40 is illustrated. The mixer 40 generally includes the inlet portion 42, the outlet portion 44, and the extended mixing conduit 46 extending therebetween.

[0030] The mixer inlet portion 42 includes a rigid canister 80 having an axis 82, and the canister 80 defines the inlet 50 and an outlet 84 of the inlet portion 42. The inlet 50 is oriented substantially perpendicular to the outlet 84, which is formed in an outer surface 86 of the canister 80. The canister 80 includes an injection area 88 configured to receive at least a portion of the reductant injector 52 for injection of the reductant 54 into the exhaust gas 18 upstream of the outlet 84.

[0031] The extended mixing conduit 46 generally includes an inlet 90, a mixing portion 92, a diffusing portion 94, and an outlet 96. As illustrated, mixing conduit 46 is curved and extends about a portion of the circumference of the mixer outlet portion 44. This provides an extended or lengthened path for mixing the exhaust gas 18 and the reductant 54 to increase residence time therein for improved mixing.

[0032] The mixing portion 92 of conduit 46 includes a decreasing diameter or cross-sectional area between inlet 90 and the beginning of diffusing portion 94, which facilitates concentrating and accelerating the flow of the exhaust gas/reductant mixture 56 to promote increased mixing thereof. The mixing portion 92 may also include a mixer device 98 positioned therein to facilitate further mixing between the exhaust gas 18 and the reductant 56. As shown in FIG. 6, in the exemplary embodiment, the mixer device 98 may include a plurality of radially extending blades 100 circumferentially spaced about a middle ring 102 that defines an aperture 104. Blades 100 facilitate inducing a swirl motion or vortex 105 (FIG. 3) in the gas mixture 56 to increase mixing of the exhaust gas 18 and the reductant 54. Further, middle ring 102 acts as a venturi and diffuser by increasing the velocity of the mixture 56 passing therethrough and diffusing the mixture 56 downstream thereof to facilitate improved mixing between the exhaust gas 18 and the reductant 54. Alternatively, any suitable mixer device may be used that enables swirl can mixer 40 to function as described herein.

[0033] The diffusing portion 94 of conduit 46 includes an increasing diameter or cross-sectional area between the beginning of diffusing portion 94 and the conduit outlet 96, which facilitates diffusing the exhaust gas/reductant mixture 56, thereby slowing the flow velocity of the mixture 56 and increase mixing between the exhaust gas 18 and the reductant 54. Diffusing portion 94 includes an inner wall 99 at least partially defining the mixing conduit 46 to extend its overall length between the conduit inlet 90 and outlet 96. As shown in FIGS. 3 and 4, the curvature of the diffusing portion 94 extends the fluid path about a portion of the circumference of swirl can mixer outlet portion 44. This facilitates both extending the length of the fluid path between mixer inlet and outlet portions 42, 44 as well as generating a larger scale, circumferential swirl 107 (FIG. 3) of the mixture 56 about outlet portion axis 58.

[0034] The internal surface shape and the position and angle of the entry of mixing conduit outlet 96 into the mixer outlet portion 44 determines the flow distribution into the downstream catalysts. For example, as shown in FIG. 5, a ratio of parameters may be a/D between approximately 0.1-0.40, b/D between approximately 0.15-0.5, and c/D between approximately 0.2-0.6. However, these ratios can be altered to balance the flow distribution and mixing for a desired overall performance.

[0035] The mixer outlet portion 44 includes a rigid canister 106 having axis 58, and the canister 106 defines an inlet 108 and the outlet 60 of the outlet portion 44. The inlet 108 is oriented substantially perpendicular to the outlet 60 and receives the mixture 56 from the outlet 96 with induced swirl components 105, 107 from both the mixer device 98 and the circumferential diffusing portion 94. The mixture 56 enters the mixer outlet portion 44 tangentially thereto, and the rotation direction of swirl components 105 and 107 are normal to each other, which break up in multiple directions within the inner volume of swirl can mixer outlet portion 44 to facilitate enhancing liquid reductant droplet vaporization and mixing with the exhaust gas 18 prior to entering the SCR device 62.

[0036] In operation of the swirl can mixer assembly 40, exhaust gas 18 flows into mixer inlet portion 42 and reductant 54 is injected into the exhaust gas 18 by the injector 52. The exhaust gas/reductant mixture 56 subsequently flows through outlet 84 to the extended mixing conduit 46.

[0037] The exhaust gas/reductant mixture 56 enters the extended mixing conduit 46 through inlet 90. The exhaust gas 18 and reductant 54 continue to mix as the diameter or cross-section of the conduit mixing portion 92 decreases, thereby increasing the velocity and mixing of the fluids 18, 54. As the mixture 56 reaches the mixer device 98, a swirl 105 is induced in a portion of the mixture 56 by blades 100 to enhance mixing, and a portion of the mixture 56 is subjected to a venturi effect produced by the middle ring 102, thereby also increasing mixture between the exhaust gas 18 and the reductant 54 across a wide range of exhaust flow rates.

[0038] The exhaust gas/reductant mixture 56 subsequently flows downstream of the mixer device 98 to the conduit diffusing portion 94, where the curved, circumferential path of portion 94 induces the circumferential swirl component 107 in the mixture that is tangential to swirl can mixer outlet portion 44 and its axis 58. Further, the increasing diameter or cross-section of the diffusing portion 94 diffuses the mixture 56, which reduces the flow velocity of mixture 56 and promotes further mixing of the exhaust gas 18 and the reductant 54 and also increases the residence time of the mixture 56 in

the outlet portion **94**. The mixture **56**, which includes swirl components **105**, **107** produced by the mixer device **98** and the circumferential diffusing portion **94**, subsequently exits the extended mixing conduit **46** through outlet **96**.

[0039] The exhaust gas/reductant mixture **56** enters the swirl can mixer outlet portion **44** through inlet **108** from extended mixing conduit **46**. The swirl components **105**, **107** of the fluid flow of mixture **56** break apart or dissipate within the canister **106**, which enhances the mixing and liquid drop-let vaporization between the exhaust gas **18** and the reductant **54**. As such, the exhaust gas **18** and the reductant **54** are sufficiently mixed prior to entering the SCR device **62**, the second OC device **76**, and/or the PF device **78** even though the exhaust treatment system **12** has a compact configuration. This is due in part to the extended length of the curved mixing conduit **46** as well as the mixing and/or vaporization promoted by the reducing diameter mixing portion **92**, the swirl components **105**, **107** induced by the mixer device **98** and curved diffusing portion **94**, the venturi/diffuser effect produced by the mixer device **98**, the fluid diffusion facilitated by expanding cross-section diffusing portion **94**, and the fluid entering the mixer outlet portion **44** tangentially thereto.

[0040] While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed, but that the invention will include all embodiments falling within the scope of the present application.

What is claimed is:

1. A swirl can mixer assembly for mixing a fluid with exhaust gas exhausted from an internal combustion engine, the assembly comprising:

an inlet portion including an injection area configured to receive a fluid injector for dispensing the fluid into the exhaust gas for mixing with the exhaust gas in the mixing assembly to produce an exhaust gas/fluid mixture; and an outlet portion; and

an extended mixing conduit fluidly coupled between the inlet portion and the outlet portion, wherein the extended mixing conduit is curved about at least a portion of a circumference of the outlet portion to induce a swirl in the exhaust gas/fluid mixture such that the exhaust gas/fluid mixture enters the outlet portion tangentially thereto.

2. The assembly of claim 1, wherein the inlet portion is a canister having an inlet and an outlet coupled to the extended mixing conduit, wherein the outlet is located downstream of the injection area.

3. The assembly of claim 2, wherein the canister includes a cylindrical outer surface, wherein the inlet portion outlet extends through the cylindrical outer surface.

4. The assembly of claim 1, wherein the outlet portion is a canister having an inlet coupled to the extended mixing conduit, and an outlet.

5. The assembly of claim 1, wherein the canister includes a cylindrical outer surface.

6. The assembly of claim 1, wherein the extended mixing conduit includes a mixing portion and a diffusing portion, wherein the mixing portion is coupled to the inlet portion and

the diffusing portion is coupled to the outlet portion, the mixing portion positioned upstream of the diffusing portion.

7. The assembly of claim 6, wherein the cross-sectional area of the mixing portion decreases along a length of the mixing portion, the decreasing cross-sectional area configured to facilitate increasing the velocity of the exhaust gas and the fluid to facilitate mixing therebetween.

8. The assembly of claim 6, wherein the cross-sectional area of the diffusing portion increases along a length of the diffusing portion, the increasing cross-sectional area configured to facilitate diffusion of the exhaust gas and the fluid to improve mixing therebetween.

9. The assembly of claim 6, further comprising a mixer device located in the mixing portion of the extended mixing conduit, the mixer device configured to facilitate mixing of the exhaust gas and the fluid.

10. The assembly of claim 9, wherein the mixer device comprises at least one of:

a plurality of blades configured to facilitate inducing a swirl in the exhaust gas/fluid mixture; and a middle ring configured to facilitate producing a venturi effect on the exhaust gas/fluid mixture passing there-through.

11. An exhaust gas treatment system configured to receive exhaust gas from an internal combustion engine, the system comprising:

a catalyst device; and

a swirl can mixer assembly for mixing a fluid with the exhaust gas, the swirl can mixer assembly comprising:

an inlet portion including an injection area;

a fluid injector coupled to the inlet portion and configured to dispense the fluid into the exhaust gas in the injection area for mixing with the exhaust gas in the mixing assembly to produce an exhaust gas/fluid mixture;

an outlet portion coupled to the catalyst device; and

an extended mixing conduit fluidly coupled between the inlet portion and the outlet portion, wherein the extended mixing conduit is curved about at least a portion of a circumference of the outlet portion to induce a swirl in the exhaust gas/fluid mixture such that the exhaust gas/fluid mixture enters the outlet portion tangentially thereto.

12. The system of claim 11, wherein the fluid injector is a reductant injector and the fluid is a reductant.

13. The system of claim 11, wherein the catalyst device is at least one of a selective catalytic reduction (SCR) device, an oxidation catalyst (OC) device, and a particulate filter (PF) device.

14. The system of claim 11, further comprising a second catalyst device coupled to the inlet portion.

15. The system of claim 14, wherein the second catalyst device is an oxidation catalyst (OC) device.

16. The system of claim 11, wherein the extended mixing conduit includes a mixing portion and a diffusing portion, wherein the mixing portion is coupled to the inlet portion and the diffusing portion is coupled to the outlet portion, the mixing portion positioned upstream of the diffusing portion.

17. The system of claim 16, wherein the cross-sectional area of the mixing portion decreases along a length of the mixing portion, the decreasing cross-sectional area configured to facilitate increasing the velocity of the exhaust gas and the fluid to facilitate mixing therebetween.

18. The system of claim 16, wherein the cross-sectional area of the diffusing portion increases along a length of the

diffusing portion, the increasing cross-sectional area configured to facilitate diffusion of the exhaust gas and the fluid to improve mixing therebetween.

19. The system of claim **16**, further comprising a mixer device located in the mixing portion of the extended mixing conduit, the mixer device configured to facilitate mixing of the exhaust gas and the fluid.

20. The assembly of claim **19**, wherein the mixer device comprises at least one of:

- a plurality of blades configured to facilitate inducing a swirl in the exhaust gas/fluid mixture; and
- a middle ring configured to facilitate producing a venturi effect on the exhaust gas/fluid mixture passing there-through.

* * * * *