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(54) **REGENERATION DEVICE HAVING AIR-ASSISTED FUEL NOZZLE**

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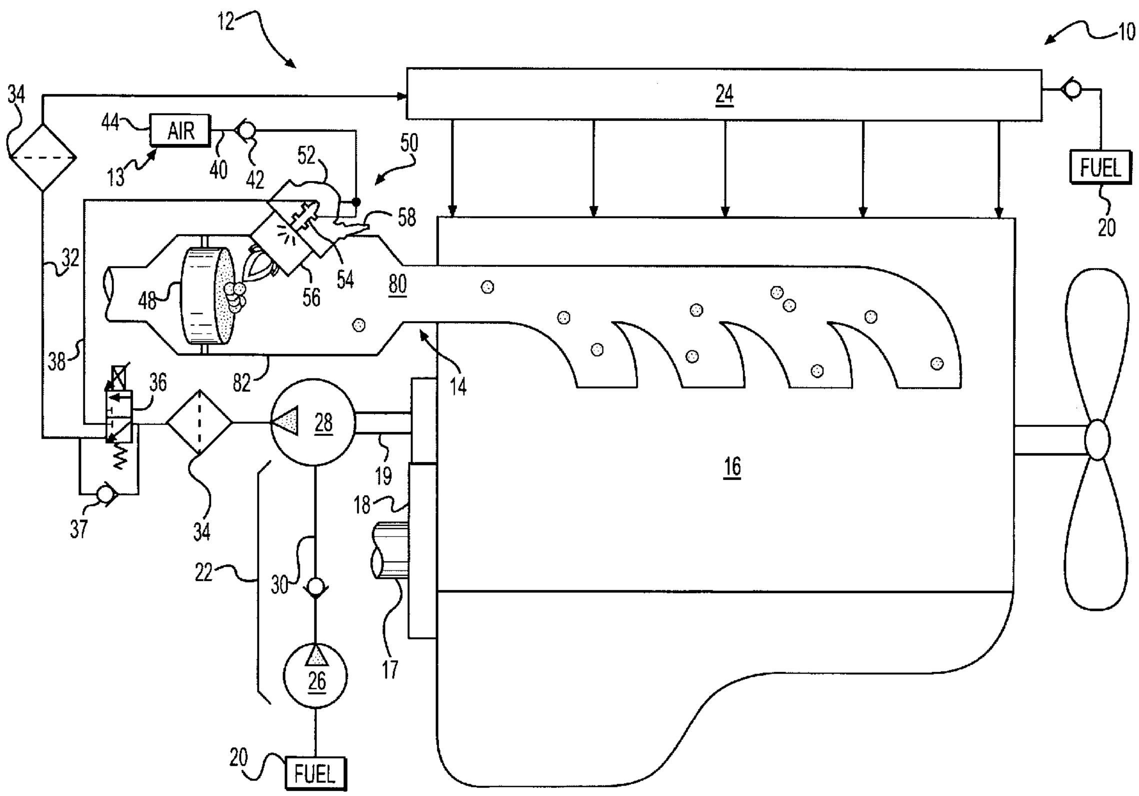
(57) **ABSTRACT**

A regeneration device for use with an exhaust treatment system is disclosed. The regeneration device may have a housing with a fuel passageway and a first air passageway. The regeneration device may also have an injector disposed in the housing in fluid communication with the fuel passageway and the first air passageway. The regeneration device may further have a combustion canister connected to receive a fuel/air mixture from the injector.



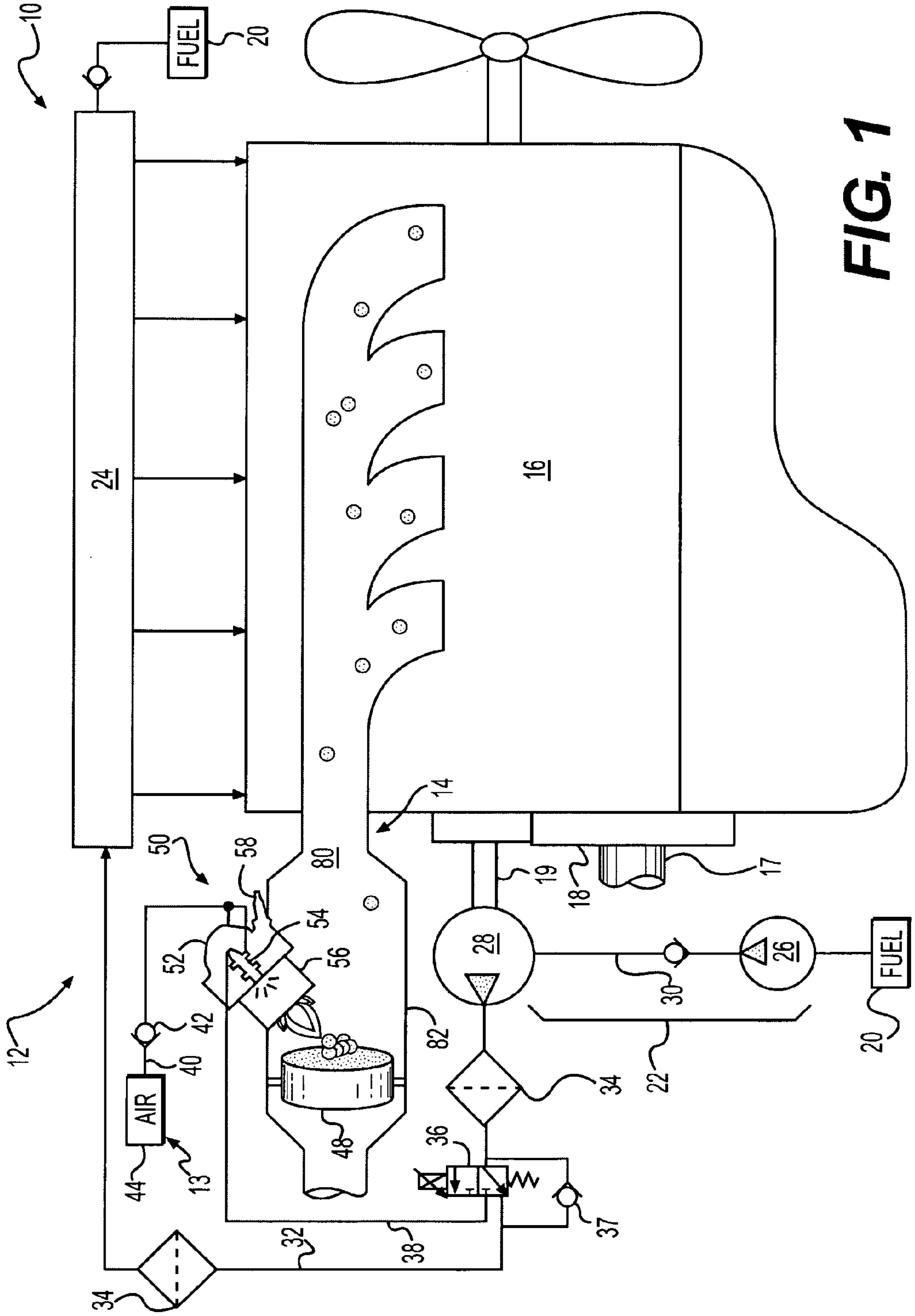


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FIG. 1

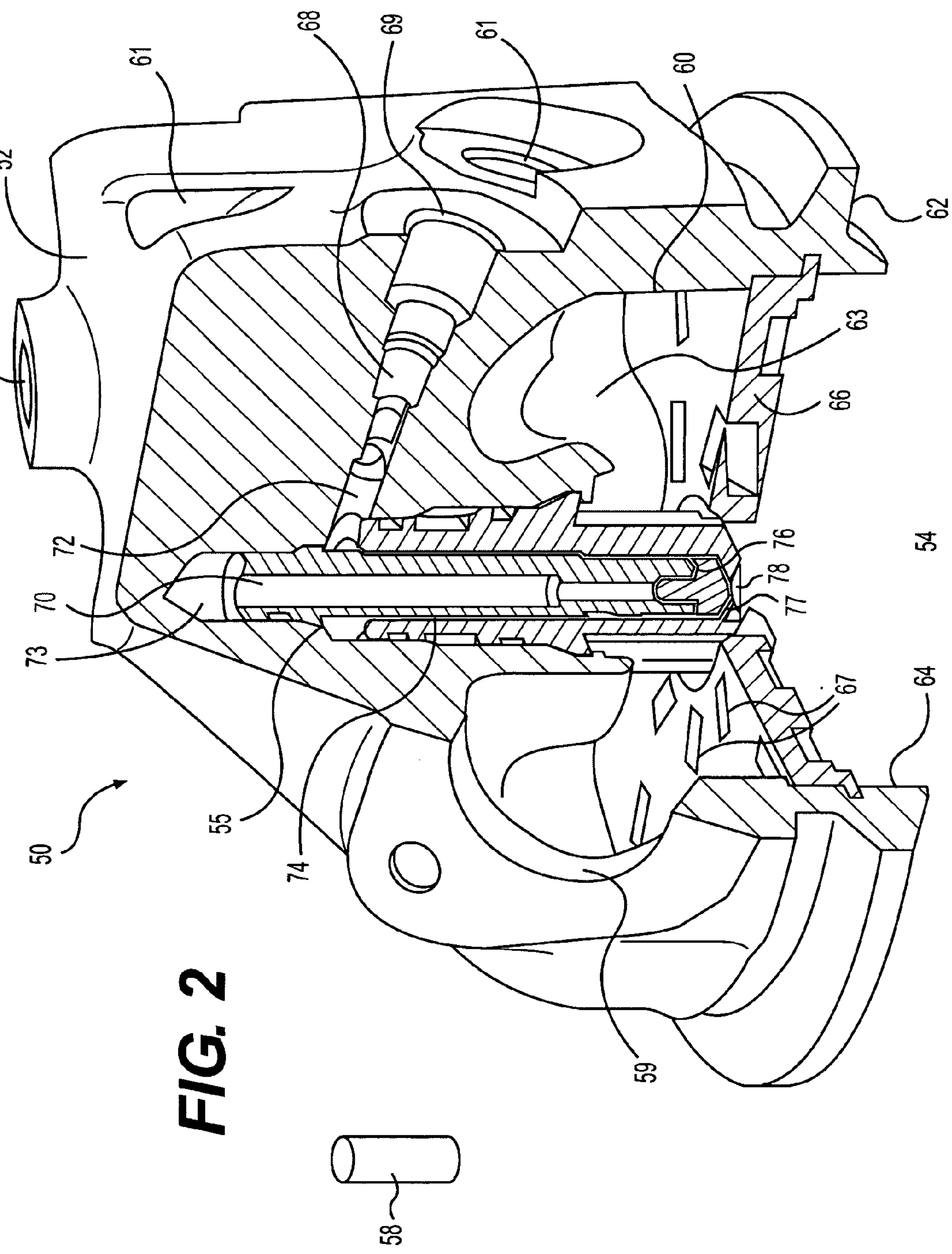

FIG. 2

REGENERATION DEVICE HAVING AIR-ASSISTED FUEL NOZZLE

TECHNICAL FIELD

[0001] The present disclosure is directed to a regeneration device and, more particularly, to a regeneration device having an air-assisted fuel nozzle.

BACKGROUND

[0002] Engines, including diesel engines, gasoline engines, gaseous fuel powered engines, and other engines known in the art exhaust a complex mixture of air pollutants. These air pollutants include solid material known as particulate matter or soot. Due to increased attention on the environment, exhaust emission standards have become more stringent, and the amount of particulate matter emitted from an engine is regulated depending on the type of engine, size of engine, and/or class of engine.

[0003] One method implemented by engine manufacturers to comply with the regulation of particulate matter exhausted to the environment has been to remove the particulate matter from the exhaust flow of an engine with a device called a particulate trap. A particulate trap is a filter designed to trap particulate matter and typically consists of a wire mesh or ceramic honeycomb medium. However, the use of the particulate trap for extended periods of time may cause the particulate matter to build up in the medium, thereby reducing the functionality of the filter and subsequent engine performance.

[0004] The collected particulate matter may be removed from the filter through a process called regeneration. To initiate regeneration of the filter, the temperature of the particulate matter entrained within the filter must be elevated to a combustion threshold, at which the particulate matter is burned away. One way to elevate the temperature of the particulate matter is to inject a catalyst such as diesel fuel into the exhaust flow of the engine and ignite the injected fuel.

[0005] Typically, the fuel is atomized during injection for efficient distribution and/or combustion purposes. The fuel is atomized by directing highly pressurized fuel through very small orifices in the injector. Although this method of atomizing the fuel maybe effective, it is also problematic. Specifically, the very small size of the orifices lends itself to frequent fouling and clogging. A fouled injector must be purged to remove the fouling, and replaced if the purging is unable to clear the restriction. In addition, the fuel pressures required for adequate atomization may be expensive to generate and difficult to accommodate.

[0006] One attempt at minimizing fouling in an exhaust treatment injector while improving atomization is described in U.S. Patent Publication No. 2006/0101810 ("the '810 publication") by Angelo et al. published on May 18, 2006. Specifically, the '810 publication discloses an emission control device having a fuel injector. Pressurized fuel and air are supplied to the fuel injector, which mixes the fuel with the air and injects the mixture into an exhaust flow through a nozzle. This injection causes a rapid pressure drop in the mixture that results in the pressurized air expanding rapidly, breaking the fuel spray into fine particles.

[0007] In one embodiment disclosed in the '810 publication, the emission control device is positioned upstream from a catalytic converter that is positioned upstream from a diesel particulate filter. When the fuel/air mixture combusts within the catalytic converter, the temperature of the exhaust gas exiting the catalytic converter and traveling to the diesel particulate filter is within a combustion temperature range of the particulate matter trapped on the filter.

[0008] In another embodiment disclosed in the '810 publication, the fuel injector can inject the fuel/air mixture directly into the diesel particulate filter without having a preheating process provided by combustion within an upstream catalytic converter. In such an embodiment, the fuel ignites with a catalyst on the diesel particulate filter, thereby causing oxidation of the particulate matter on the filter.

[0009] Although the emission control device of the '810 publication may improve atomization and reduce the likelihood of fouling, its use may be limited. Specifically, the emission control device is only a dosing system (i.e., it does not actively ignite the injected fuel/air mixture), which may be operable only at certain engine conditions when the temperature of the exhaust is already above a predetermined threshold. In situations where the exhaust temperatures are below the predetermined threshold, the emission control device may be unable to regenerate the particulate trap.

[0010] In addition, because the emission control device of the '810 publication relies on a catalyst for ignition and combustion of the injected fuel/air mixture, the component and maintenance costs of the device may be significant. In particular, the additional catalyst component may increase the initial cost of the device, while service and/or replacement of the catalyst component may increase the maintenance cost. Further, it may be possible that combustion of the injected fuel/air mixture becomes unreliable as the catalyst ages and/or is consumed.

[0011] The regeneration device of the present disclosure solves one or more of the problems set forth above.

SUMMARY OF THE DISCLOSURE

[0012] One aspect of the present disclosure is directed to a regeneration device. The regeneration device may include a housing having a fuel passageway and a first air passageway. The regeneration device may also include an injector disposed in the housing in fluid communication with the fuel passageway and the first air passageway. The regeneration device may further include a combustion canister connected to receive a fuel/air mixture from the injector and combustion air line.

[0013] Another aspect of the present disclosure is directed to a method of regenerating a particulate trap that receives a flow of exhaust. The method may include mixing fuel with air prior to an injection event, and injecting the mixture of fuel and air to atomize the fuel during the injection event. The method may further include igniting the atomized fuel outside of the flow of exhaust, and introducing the ignited fuel/air mixture into the flow of exhaust upstream of the particulate trap.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. **1** is a schematic and diagrammatic illustration of an exemplary disclosed power unit; and

[0015] FIG. **2** is a cutaway view illustration of an exemplary disclosed regeneration device for use with the power unit of FIG. **1**.

DETAILED DESCRIPTION

[0016] FIG. **1** illustrates a power unit **10** having a fuel system **12**, an air assist system **13**, and an exhaust aftertreatment system **14**. In one embodiment, power unit **10** may be associated with a mobile vehicle such as a passenger vehicle, a vocational vehicle, a farming vehicle or a construction vehicle. Alternatively, power unit **10** may be associated with a stationary machine such as an industrial power generator or a furnace.

[0017] For the purposes of this disclosure, power unit **10** is depicted and described as a four-stroke diesel engine. One skilled in the art will recognize, however, that power unit **10** may be any other type of internal combustion engine such as, for example, a gasoline or a gaseous fuel-powered engine. Power unit **10** may include an engine block **16** that at least partially defines a plurality of combustion chambers (not shown). In the illustrated embodiment, power unit **10** includes four combustion chambers. However, it is contemplated that power unit **10** may include a greater or lesser number of combustion chambers and that the combustion chambers may be disposed in an "in-line" configuration, a "V" configuration, or any other suitable configuration.

[0018] As also shown in FIG. **1**, power unit **10** may include a crankshaft **17** that is rotatably disposed within engine block **16**. A connecting rod (not shown) may connect a plurality of pistons (not shown) to crankshaft **17** so that a sliding motion of each piston within the respective combustion chamber results in a rotation of crankshaft **17**. Similarly, a rotation of crankshaft **17** may result in a sliding motion of the pistons. Rotation of crankshaft **17** may function as output from power unit **10** for effecting a desired work such as rotation of a generator or rotation of one or more drive axles of an associated vehicle.

[0019] Fuel system **12** may include components that cooperate to deliver injections of pressurized fuel into each of the combustion chambers. Specifically, fuel system **12** may be a common rail fuel system and may include a tank **20** configured to hold a supply of fuel such as diesel fuel, and a fuel pumping arrangement **22** configured to pressurize the fuel and direct the pressurized fuel to a plurality of fuel injectors (not shown) by way of a rail **24**.

[0020] Fuel pumping arrangement **22** may include one or more pumping devices that function to increase the pressure of the fuel and direct one or more pressurized streams of fuel to rail **24**. In one example, fuel pumping arrangement **22** may include a low pressure source **26** and a high pressure source **28** disposed in series and fluidly connected by way of a fuel line **30**. Low pressure source **26** may embody a transfer pump that provides low pressure feed to high pressure source **28**. High pressure source **28** may receive the low pressure feed and increase the pressure of the fuel up to as much as 300 MPa in some cases. High pressure source **28** may be connected to rail **24** by way of a fuel line **32**. One or more filtering elements **34**, such as a primary filter and a secondary filter, may be disposed within fuel line **32** in series relation to remove debris and/or water from the fuel pressurized by fuel pumping arrangement **22**.

[0021] One or both of low and high pressure sources **26**, **28** may be operatively connected to power unit **10** and driven by crankshaft **17**. Low and/or high pressure sources **26**, **28** may be connected to crankshaft **17** in any manner readily apparent to one skilled in the art where a rotation of crankshaft **17** will result in a corresponding driving rotation of a pump shaft. For example, a pump driveshaft **19** of high pressure source **28** is shown in FIG. **1** as being connected to crankshaft **17** through a gear train **18**. It is contemplated, however, that one or both of low and high pressure sources **26**, **28** may alternatively be driven electrically, hydraulically, pneumatically, or in any other appropriate manner. It is further contemplated that fuel system **12** may alternatively embody another type of fuel system such as, for example, a mechanical unit fuel injector system or a hydraulic unit fuel injector system where the pressure of the injected fuel is generated or enhanced within individual injectors without the use of a high pressure source.

[0022] Fuel system **12** may also include components for redirecting a portion of the pressurized fuel to exhaust aftertreatment system **14**. For example, as illustrated in FIG. **1**, fuel system **12** may further include a fuel metering valve **36** and a check valve **37**, both disposed along fuel line **32** and configured to selectively redirect any desired portion of the pressurized fuel to exhaust aftertreatment system **14** via an additional fuel line **38**.

[0023] Air assist system **13** may pressurize a fluid, such as air, and provide this pressurized fluid to exhaust aftertreatment system **14** for combustion purposes. For example, compressed air may be directed to mix with injections of fuel from high pressure source **28** and, thereby, aid combustion within exhaust aftertreatment system **14**. For these purposes, air assist system **13** may include a fluid supply **44** such as, for example, a compressor, an air pump, or any other suitable source, and a storage reservoir, such as a tank or an accumulator having sufficient volume to complete a combustion process with or without operation of fluid supply **44**. A fluid line **40** may fluidly connect fluid supply **44** to the components of exhaust aftertreatment system **14** at any upstream location. A check valve **42** may be disposed within fluid line **40** to ensure that fuel and other contaminates are blocked from flowing through fluid line **40** to fluid supply **44**. The flow of fluid through fluid line **40** may be controlled by way of a suitable valve arrangement (not shown).

[0024] Exhaust aftertreatment system **14** may include an exhaust manifold **80** configured to expel exhaust generated by power unit **10** towards a housing **82** located downstream from exhaust manifold **80**. Housing **82** of exhaust aftertreatment system **14** may be a cylindrical or tubular conduit for directing exhaust gasses and particulates away from power unit **10** for processing by various emission controlling devices. That is, housing **82** may constitute structural support for an aftertreatment device **48**.

[0025] Aftertreatment device **48** may be disposed across the cylindrical width (i.e., cross section) of housing **82** and either removably or fixedly secured at its perimeter to housing **82**. Aftertreatment device **48** may be any variety of diesel particulate filter ("DPF") such as, for example, a corderite or silicon carbide wall-flow filter, a metal fiber flow-through filter or a partial flow filter. As exhaust from power unit **10** flows through aftertreatment device **48**, exhaust constituents such as particulate matter may be removed from the exhaust flow by aftertreatment device **48**. According to one embodiment of the present disclosure, aftertreatment device **48** may have about 99% efficiency of particulate filtration. Moreover, it is contemplated that exhaust aftertreatment system **14** may include other components such as, for example, a turbine, an exhaust gas recirculation system, a catalytic treatment device, or any other exhaust system component known in the art.

[0026] Over time, the particulate matter may build up in aftertreatment device **48** and, if left unchecked, the particulate matter buildup could be significant enough to restrict or even block the flow of exhaust through aftertreatment device **48**, allowing backpressure within the power unit **10** to increase. An increase in the backpressure of power unit **10** could reduce the power unit's ability to draw in fresh air, resulting in decreased performance, increased exhaust temperatures, and poor fuel consumption. Therefore, exhaust aftertreatment system **14** may include a regeneration device **50**, in fluid communication with housing **82**, fuel system **12**, and air assist system **13**.

[0027] Regeneration device **50** may include components configured to periodically reduce the buildup of particulate matter within aftertreatment device **48**. For example, regeneration device **50** may include a housing **52**, an injector **54**, a combustion canister **56**, an ignition device **58**, and any other components configured to convey fluids thereto or therebetween. Generally, housing **52** may receive and fluidly connect pressurized fuel from fuel line **38** and pressurized air from fluid line **40** with injector **54**. Accordingly, regeneration device **50** may supply a mixture of fuel and air, and combust the mixture at a location proximate aftertreatment device **48** for oxidizing and releasing the particulates entrained therein.

[0028] It is contemplated that exhaust aftertreatment system **14** may include additional or different components such as, for example, one or more control valves, a controller, a pressure sensor, a flow sensor, a flow blocking device, and other components known in the art. It is further contemplated that exhaust aftertreatment system **14** may also include a Selective Catalytic Reduction (SCR) device and an associated injector (not shown) nearly identical to injector **54** for introducing a reductant such as, for example, urea into the exhaust flow upstream of the SCR device.

[0029] FIG. **2** illustrates one embodiment of regeneration device **50**. In this embodiment, housing **52** of regeneration device **50** may include a central stepped bore **55** and an annular bore **60**. Annular bore **60** may define a substantially torroidal air chamber **63** disposed about central stepped bore **55**. Housing **52** may also include a first air inlet **69** and a fuel inlet **71**, both in fluid communication with central stepped bore **55**. In one embodiment, housing **52** may include an air passageway **68** to provide fluid communication between first air inlet **69** and central stepped bore **55**. Housing **52** may further include a fuel passageway (not shown) to provide fluid communication between fuel inlet **71** and central stepped bore **55**. Accordingly, first air inlet **69** and air passageway **68** may provide a fluid link between fluid line **40** of air assist system **13** and central stepped bore **55**. Moreover, fuel inlet **71** and the fuel passageway (not shown) may provide a fluid link between fuel line **38** of fuel system **12** and central stepped bore **55**. Housing **52** may further include a second air inlet **59** in fluid communication with annular bore **60**. Second air inlet **59** may convey air, which may be unmixed with fuel, from an external surface of the housing, to annular bore **60** for use in combustion. For example, second air inlet **59** may provide a fluid link between fluid line **40** of air assist system **13** and air chamber **63**. It is contemplated that a separate combustion air source (not shown) may be provided, if desired. Housing **52** may also include a plurality of coolant passageways **61** disposed in any desirable configuration for providing thermal treatment to particular locations of regeneration device **50**.

[0030] Central stepped bore **55** may receive injector **54** such that it is axially oriented toward combustion canister **56**. Injector **54** may divide central stepped bore **55** into at least two coaxial and concentric fluid passageways. For example, injector **54** may include a central passageway **70**, in fluid communication with fuel inlet **71** via central stepped bore **55**. Injector **54** may also include an outer annular passageway **74** running coaxially and concentrically with central passageway **70**. Annular passageway **74** may be in fluid communication with first air inlet **69** via air passageway **68** and central stepped bore **55**. Injector **54** may also include an injector tip **77** having slotted passageways **76**, which extend radially outward from central passageway **70** to annular passageway **74**, as well as a nozzle opening **78**. According to this embodiment, first air inlet **61**, air passageway **68**, and annular passageway **74** may provide a relatively fluid impermeable air circuit **72** for conveying air from fluid line **40** to injector tip **77**. Fuel inlet **71**, central passageway **70**, and slotted passageways **76** may provide a relatively fluid impermeable fuel circuit **73** for conveying fuel from fuel line **38** to injector tip **77**. One or more check valves (not shown) may be situated in any one or all of these passageways, if desired, to ensure unidirectional flow of the respective fluids and/or to minimize the volumes thereof that could require periodic purging.

[0031] Injector **54** may create a mixture of fuel and air within injector tip **77** as pressurized fuel travels through central passageway **70** and outwards through slotted passageways **76** to intersect with pressurized air traveling through annular passageway **74**. Injector **54** may direct the mixture of fuel and air out of injector tip **77** through nozzle opening **78**. Injector **54** may therefore provide a desirably atomized fuel spray to combustion canister **56**. Injector **54** may be operable to inject the atomized fuel/air mixture into combustion canister **56** at predetermined timings, pressures, and flow rates. The timing of injection into canister **56** may be synchronized with sensory input received from a thermocouple (not shown), one or more pressure sensors (not shown), a timer (not shown), or any other similar sensory devices such that the injections of fuel substantially correspond with a buildup of particulate matter within aftertreatment device **48** (referring to FIG. **1**). For example, fuel and air may be injected as the temperature of the exhaust flowing through aftertreatment device **48** exceeds a predetermined value. Alternatively or additionally, fuel and air may be injected as a pressure of the exhaust flowing through aftertreatment device **48** exceeds a predetermined pressure level or a pressure drop across aftertreatment device **48** exceeds a predetermined differential value. In is contemplated that fuel and air may also be injected on a set periodic basis, in addition to or regardless of pressure and temperature conditions, if desired.

[0032] Housing **52** may further include an ignition device **58** received through an external surface (not shown) of housing **52** for ignition of the atomized fuel from injector **54**. In particular, ignition device **58** may include external threads that engage internal threads of housing **52**. During a regeneration event or when a catalyst within aftertreatment device **48** requires an elevated temperature, the temperature of the exhaust exiting power unit **10** may be too low to cause auto-ignition of the fuel and air sprayed from injector **54**. To initiate combustion of the fuel/air mixture and, subsequently, the trapped particulate matter, the mixture may be sprayed or otherwise injected toward ignition device **58** to create a locally rich atmosphere readily ignitable by ignition device **58**. In an embodiment in which ignition device **58** is a spark plug, a spark therefrom may ignite the fuel/air mixture creating a flame, which may be jetted or otherwise advanced toward the trapped particulate matter. As the fuel/air mixture ignites, the temperature may rise to a level that causes combustion of the particulate matter trapped within aftertreatment device **48** and/or to a level that supports efficient operation of a catalyst. It is further contemplated that ignition device **58** may alternatively include an electrical heater to reduce any fouling of the injector tip **77**, if desired.

[0033] Housing **52** may still further include a depending flange **62** having a central recessed opening **64**. Central recessed opening **64** may receive a swirler plate **66**. Swirler plate **66** may be an annular planar member disposed around injector tip **77** and within central recessed opening **64** of flange **62**. Swirler plate **66** may be press-fitted completely within central recessed opening **64** and/or held in place with a snap ring. Swirler plate **66** may also be centrally aligned with injector **54** and housing **52**, and angularly oriented with respect to housing **52** by way of one or more dowel pins.

[0034] Swirler plate **66**, together with annular bore **60** of housing **52**, may define air chamber **63**, which may be supplied with compressed combustion air via second air inlet **59**. Swirler plate **66** may include a plurality of annularly disposed air vents **67** fluidly communicating air from air chamber **63** with combustion canister **56**. Air vents **67** may mix combustion air from second air inlet **59** with the mixture of fuel and air from injector **54** inside combustion canister **56** to improve combustion therein. Air vents **67** may be oriented in alternating or opposite directions so as to generate cross flow throughout combustion canister **56**. It is contemplated that air vents **67** may additionally or alternatively direct pressurized air to the outer periphery of combustion canister **56** for cooling and/or insulating purposes, if desired. Swirler plate **66** may also include openings (not shown) to accommodate ignition device **58**.

[0035] Depending flange **62** of housing **52** may receive and seat an annular end of combustion canister **56**. Combustion canister **56** (referring to FIG. **1**) may embody a tubular member used to axially direct an ignited fuel/air mixture (i.e., the flame jet) from regeneration device **50** into the exhaust flow through aftertreatment device **48**. In particular, combustion canister **56** may include a central opening that fluidly communicates fuel and air from injector **54**, and air from air chamber **63**, with the exhaust flow. Combustion canister **56** may employ a flame stabilizing plate (not shown) at one end to provide a restriction that minimizes pulsations within regeneration device **50**. Combustion canister **56** may be generally straight and have a predetermined length set during manufacture according to a desired flame introduction location (the distance that a flame resulting from the ignition of the fuel/air mixture extends from combustion canister **56** into the exhaust flow). In one example, this desired introduction location may be about twelve inches from the flame stabilizing plate of combustion canister **56**.

Industrial Applicability

[0036] The regeneration device of the present disclosure may be applicable to a variety of exhaust treatment devices requiring selectively elevated temperatures for regeneration. For example, the disclosed regeneration device may elevate temperatures in an aftertreatment device of a power unit by injecting an atomized mixture of fuel and air, igniting the atomized mixture, and directing the ignited mixture toward the aftertreatment device of the power unit. By using air assist for generating the atomized mixture of fuel and air, the presently disclosed regeneration device may obviate the need for small, easily-clogged injector orifices and high pressure fuel injection. The operation of power unit **10** will now be explained.

[0037] Referring to FIG. **1**, air and fuel may be drawn into combustion chambers (not shown) of power unit **10** for subsequent combustion. Specifically, fuel from fuel system **12** may be injected into combustion chambers of power unit **10**, mixed with the air therein, and combusted to produce a mechanical work output and an exhaust flow of hot gases. The exhaust flow may contain a complex mixture of air pollutants composed of gaseous and solid material, which can include particulate matter. As this particulate laden exhaust flow is directed from power unit **10** through exhaust manifold **80**, particulate matter may be strained from the exhaust flow by aftertreatment device **48**. Over time, the particulate matter may build up in aftertreatment device **48** and, if left unchecked, the buildup could be significant enough to restrict, or even block the flow of exhaust. As indicated above, the restriction of exhaust flow from power unit **10** may increase the backpressure of power unit **10** and reduce the unit's ability to draw in fresh air, resulting in decreased performance of power unit **10**, increased exhaust temperatures, and poor fuel consumption.

[0038] Aftertreatment device **48** may be regenerated to prevent the undesired buildup of particulate matter therein. Regeneration may be periodic or based on a triggering condition such as, for example, an elapsed time of engine operation, a pressure differential measured across aftertreatment device **48**, a temperature of the exhaust flowing from power unit **10**, or any other condition known in the art.

[0039] In preparation for regeneration of aftertreatment device **48**, fuel system **12** may provide a supply of pressurized fuel to regeneration device **50** via fuel line **38**, and air assist system **13** may provide a supply of pressurized air to regeneration device **50** via fluid line **40**. Pressurized fuel may enter regeneration device **50** at fuel inlet **71** and flow to injector **54** in central stepped bore **55**. Fuel may flow through central passageway **70** of injector **54** in the direction of injector tip **77** and radially outward towards annular passageway **74** through slotted passageways **77**. Pressurized air may simultaneously enter regeneration device **50** at first air inlet **69** and flow through air passageway **68** to injector **54** in central stepped bore **55**. Air may flow through annular passageway **74** of injector **54** and may be intersected and mixed with fuel flowing through slotted passageways **76**, as it approaches injector tip **77**. A fuel/air mixture may therefore be generated within injector tip **77** and then expelled out through nozzle opening **78**. As the fuel/air mixture exits nozzle opening **78**, a rapid pressure drop in the mixture may result in rapid expansion and break down of the fuel into atomized particles.

[0040] Simultaneously, combustion air may enter annular bore **60** of regeneration device **50** through second air inlet **59**. Combustion air within air chamber **63** may be directed into combustion canister **56** through air vents **67**. Due to the angles of air vents **67**, combustion air entering combustion canister **56** may cross-flow and mix with atomized fuel spray from injector **54**.

[0041] To initiate regeneration, the atomized fuel from injector **54** and combustion air from air chamber **63** may be selectively injected into combustion canister **56** at a desired rate, and ignited. As an injection of atomized fuel and air sprays into combustion canister **56**, a spark from ignition device **58** may ignite the atomized fuel and air. Alternatively, heat from an electrical coil or another ignition source may ignite the atomized fuel and air. Combustion canister **56** may direct the ignited fuel and air into housing **82** of exhaust manifold **80** and toward aftertreatment device **48**. The ignited flow of fuel and air may raise the temperature of particulate matter trapped within aftertreatment device **48** to the combustion threshold of the entrapped particulate matter, thereby, burning away the particulate matter and regenerating aftertreatment device **48**.

[0042] Because the presently disclosed regeneration device atomizes the fuel by mixing it with pressurized air prior to injection, reliance on high pressure fuel injection may be obviated. For example, conventional methods for generating atomized fuel, such as high-pressure sources and small nozzle orifices may be unnecessary. The use of larger nozzle orifices in the presently disclosed regeneration device may be advantageous due to their lower sensitivity to debris. Therefore, the orifices may be more robust and less likely to clog or foul. Moreover, the ability to use standard fuel pressure reduces the need for expensive and complex fuel systems, which employ dual-fuel supplies and complicated algorithms to achieve high atomization pressures. Accordingly, manufacturing, maintenance, and replacement costs of the present system are reduced.

[0043] Still further, because the presently disclosed regeneration device actively ignites the injected fuel/air mixture, it may be operated at any engine condition, including in situations where the exhaust temperatures are below a threshold for passive regeneration. Therefore, the system may be more reliable and may ensure continued and successful regeneration events in an efficient manner with components having a prolonged useful life.

[0044] It will be apparent to those skilled in the art that various modifications and variations can be made to the regeneration device of the present disclosure without departing from the scope of the disclosure. Other embodiments will be apparent to those skilled in the art from consideration of the specification and practice of the regeneration device disclosed herein. For example, although the disclosed regeneration device is illustrated as drawing pressurized fuel from a fuel system, the disclosed regeneration device may alternatively draw pressurized fuel from a separate dedicated source, if desired. Further, although general examples have illustrated the disclosed regeneration device as being associated with fuel for particulate regeneration purposes, it is contemplated that injector **54** may just as easily be adapted to inject ammonia, AdBlue, and/or urea within a Selective Catalytic Reduction (SCR) device, if desired. It is intended that the specification and examples be considered as exemplary only, with a true scope of the disclosure being indicated by the following claims and their equivalents.

What is claimed is:

1. A regeneration device, comprising:

a housing having a fuel passageway and a first air passageway;

an injector disposed in the housing in fluid communication with the fuel passageway and the first air passageway and configured to mix fuel with air; and

a combustion canister connected to receive a fuel/air mixture from the injector.

2. The regeneration device of claim **1**, wherein the housing further includes a second air passageway in fluid communication with the combustion canister to supply unmixed air directly to the combustion canister.

3. The regeneration device of claim **2**, wherein the second air passageway annularly surrounds the injector and directs the unmixed air into the combustion canister at a plurality of locations.

4. The regeneration device of claim **1**, wherein the combustion canister houses a combustion of the fuel/air mixture.

5. The regeneration device of claim **4**, wherein the combustion canister directs the combustion out of the combustion canister into an exhaust flow.

6. The regeneration device of claim **4**, further including an ignition source that ignites the fuel/air mixture as it enters the combustion canister.

7. The regeneration device of claim **6**, wherein the ignition source is a spark plug.

8. The regeneration device of claim **6**, wherein the ignition source is a heater.

9. A method of regenerating a particulate trap that receives a flow of exhaust, comprising:

mixing fuel with air prior to an injection event;

injecting the mixture of fuel and air to atomize the fuel during the injection event;

igniting the atomized fuel outside of the flow of exhaust; and

introducing the ignited fuel/air mixture into the flow of exhaust upstream of the particulate trap.

10. The method of claim **9**, further including directing combustion air to an ignition location.

11. The method of claim **10**, wherein directing combustion air includes directing multiple jets of combustion air to the ignition location.

12. The method of claim **9**, wherein igniting includes heating a localized area at the ignition location.

13. The method of claim **9**, wherein heating includes generating a current discharge.

14. An exhaust treatment system for a combustion unit, comprising:

a passageway configured to receive a flow of exhaust from the combustion unit;

a particulate trap located within the passageway to remove particulate matter from the flow of exhaust; and

a regeneration device located upstream of the particulate trap to facilitate oxidation of the removed particulate matter, the regeneration device including:

a housing having a fuel passageway, an atomizing air passageway, and a combustion air passageway;

an injector disposed in the housing in fluid communication with the fuel passageway and the atomizing air passageway and configured to mix fuel with air; and

a combustion canister connected to the housing to receive a fuel/air mixture from the injector and unmixed air from the combustion air passageway, house a combustion of the fuel/air mixture, and direct the combustion from the combustion canister into the flow of exhaust.

15. The exhaust treatment system of claim **14**, wherein the combustion air passageway annularly surrounds the injector and directs the unmixed air into the combustion canister at a plurality of locations.

16. The exhaust treatment system of claim **14**, further including an ignition source that ignites the fuel/air mixture as it enters the combustion canister.

17. The exhaust treatment system of claim 16, wherein the ignition source is a spark plug.

18. The exhaust treatment system of claim 16, wherein the ignition source is a heater.

19. The exhaust treatment system of claim 14, further including:

a source of fuel in communication with the fuel passageway; and

a source of air in fluid communication with the atomizing air passageway and the combustion air passageway.

20. The exhaust treatment system of claim 19, wherein the source of air is dedicated to supplying air to only the regeneration device, and supplies air at a substantially constant flow rate.

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