EXHAUST THROTTLE VALVE SYSTEM AND METHOD FOR DIESEL PARTICULATE FILTER REGENERATION

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ABSTRACT

An exhaust gas aftertreatment system (10) for a vehicle having an engine (14) includes a fluid passageway (20) extending from the engine to an ambient (18) for fluidly communicating exhaust gas (F). A diesel particulate filter (24) is disposed on the fluid passageway (20) downstream of the engine (14). At least one exhaust throttle valve (30A-30D) is located downstream of the engine (14) on the fluid passageway (20). When the exhaust throttle valve (30A-30D) is actuated, the valve obstructs the flow of exhaust gas (F) and increases the temperature of the exhaust gas. The heated exhaust gas (F) causes regeneration at the diesel particulate filter (24).
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BACKGROUND

[0001] Embodiments described herein relate to a system and method for heating exhaust gas. More specifically, embodiments described herein relate to a system and method for heating exhaust gas to create a regeneration event at a diesel particulate filter.

[0002] Exhaust gas aftertreatment systems in diesel vehicles are located downstream of the engine for treating exhaust gases emitted from the engine. The aftertreatment systems typically include a diesel oxidation catalyst, a diesel particulate filter, among other components. Particulate matter from the exhaust gas accumulates on the diesel particulate filter, and if left unchecked, can create a back pressure in the aftertreatment system.

[0003] A regeneration event is the periodic oxidation of the collected particulate matter in the aftertreatment system during routine diesel engine operation. When the diesel particulate filter of the exhaust system experiences a build-up of particulate matter, the particulate matter is oxidized to “regenerate” the filter. Regeneration is typically initiated by increasing engine load and activating a post-injection of diesel fuel into the exhaust stream. This post-injection provides sufficient heat to oxidize the trapped particulate matter within the diesel particulate filter.

[0004] During idling or part load operating conditions, fuel injected into the combustion cycle is not enough to maintain exhaust gas temperature sufficient to start the DPF regeneration cycle. As such, the loading of the engine must be increased to provide a sufficiently heated exhaust gas to initiate the regeneration downstream at the diesel particulate filter. However many vehicles operate on a "stop and drive" or frequent idling basis, and the resulting exhaust gas may not have a sufficiently high temperature to initiate the regeneration.

SUMMARY

[0005] An exhaust gas aftertreatment system for a vehicle having an engine includes a fluid passageway extending from the engine to an ambient for fluidly communicating exhaust gas. A diesel particulate filter is disposed on the fluid passageway downstream of the engine. At least one exhaust throttle valve is located downstream of the engine on the fluid passageway. When the exhaust throttle valve is actuated, the valve obstructs the flow of exhaust gas and increases the temperature of the exhaust gas. The heated exhaust gas causes regeneration at the diesel particulate filter.

[0006] A method of regenerating an exhaust aftertreatment system of an engine having a diesel particulate filter includes providing a fluid passageway from the engine to an ambient. The method also includes the step of providing an exhaust throttle valve downstream of the engine on the fluid passageway, and actuating the exhaust throttle valve to at least partially obstruct the flow of exhaust gas through the fluid passageway. Further, the method includes compressing and heating the exhaust gas upstream of the exhaust throttle valve, and delivering the heated exhaust gas to the diesel particulate filter to initiate regeneration.

[0007] An exhaust gas aftertreatment system for a vehicle having an engine includes an engine control module associated with the engine, a fluid passageway extending from the engine to an ambient for fluidly communicating exhaust gas, and a diesel particulate filter disposed on the fluid passageway downstream of the engine. The system also includes at least one exhaust throttle valve located downstream of the diesel particulate filter on the fluid passageway, and an actuator for actuating the at least one exhaust throttle valve. At least a temperature sensor for sensing the temperature at the aftertreatment system, or a back pressure sensor for sensing the pressure at the aftertreatment system, communicate the temperature or the back pressure, or both, to an engine control module on the engine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a schematic of an exhaust aftertreatment system having an exhaust throttle valve located upstream of the diesel particulate filter.

[0009] FIG. 2 is a schematic of the exhaust aftertreatment system having the exhaust throttle valve located downstream of the diesel particulate filter.

[0010] FIG. 3 is a schematic of the exhaust aftertreatment system having exhaust throttle valves located both upstream and downstream of the diesel particulate filter.

DETAILED DESCRIPTION

[0011] Referring to FIGS. 1-3, an exhaust gas aftertreatment system for a vehicle is indicated generally at 10, and has an exhaust pipe assembly 12 extending from an engine 14 to an outlet 16, such as the outlet to an ambient 18. The exhaust pipe assembly 12 forms a fluid passageway 20 for the flow of exhaust gas F from the engine 14 to the ambient 18. The downstream direction of exhaust gas flow F is from engine 14 to outlet 16.

[0012] A first portion 22 of the exhaust pipe assembly 12 extends from the engine 14 to a diesel particulate filter (DPF) 24. The DPF 24 is a filter constructed from a very high temperature resistant material. The DPF 24 catches and holds particulate matter entrained within the exhaust gases discharged into the exhaust aftertreatment system 10. The DPF 24 is periodically regenerated to limit increases in exhaust aftertreatment system 10 back pressure and to maintain engine 14 efficiency. A second portion 26 of the exhaust pipe assembly 12 extends from the DPF 24 to the outlet 16. An exhaust manifold 28 may be located upstream of the first portion 22 of the exhaust pipe assembly 12. Other components may be disposed on the aftertreatment system 10, such as a diesel oxidation catalyst (not shown) which may be located upstream of the DPF 24.

[0013] Referring now to FIG. 1, at least one exhaust throttle valve 30A is disposed in fluid communication with and downstream from the engine 14 on the fluid passageway 20. When actuated, the exhaust throttle valve 30A obstructs the flow of exhaust gas F through the fluid passageway 20.

[0014] The exhaust throttle valve 30A may be a butterfly valve 32A, however other types of valves are possible. The butterfly valve 32A regulates the flow F through the fluid passageway 20 with an actuator 34A, which rotates the butterfly valve 32A to be either parallel with the flow F, which is an open position, or perpendicular with the flow F, which is a closed position, or in any position therebetween. The butterfly valve 32A obstructs the flow of exhaust gas F through the exhaust passageway 20. In the parallel-open position, the orifice at the butterfly valve 32A has a maximum orifice area.
with the least flow obstruction, and in the perpendicular-closed position, the orifice at the butterfly valve has a minimum orifice area with the most flow obstruction. In the perpendicular-closed position, the exhaust throttle valve 30A may sealingly prevent the fluid communication through the second portion 26 of the exhaust pipe assembly 12.

[0015] The actuator 34A may be either hydraulically or electrically driven. An engine control module (ECM) 36 controls the exhaust throttle valve 30A through the actuator 34A depending on pressure and temperature conditions in the aftertreatment system 10. A pressure sensor communicates the pressure in the aftertreatment system 10, such as at the exhaust manifold 28 or the DPF 24, and communicates the back pressure to the ECM 36. It is possible that the back pressure can be a change in pressure between two locations on the aftertreatment system 10, such as upstream and downstream of the DPF 24.

[0016] A temperature sensor 38 senses the temperature at the DPF 24, the exhaust manifold 28, or anywhere between cylinders 44 and the outlet 16, and communicates the temperature to the ECM 36. It is possible that the temperature can be a change in temperature between two locations on the aftertreatment system 10, such as upstream and downstream of the DPF 24. The ECM 36 also monitors fuel delivery and engine speed to maintain an optimized engine speed/loading and exhaust gas temperature.

[0017] Below the predetermined temperature of exhaust manifold 28 or DPF 24, or above the predetermined amount of back pressure in the aftertreatment system 10, the DPF may be clogged with particulate matter. When a predetermined amount of exhaust back pressure is sensed by an exhaust pressure sensor 40, or when a predetermined temperature is sensed at the DPF 24, at the exhaust manifold 28, or anywhere else on the aftertreatment system 10, it is communicated to the ECM 36, which actuates the exhaust throttle valve 30A. The pressure and temperature values are communicated to the ECM 36, and the ECM commands the actuation of the exhaust throttle valve 30A to partially or completely close. In one embodiment, the butterfly valve 32A closes about 80-96% of the orifice in the fluid passageway 20.

[0018] The exhaust throttle valve 30A is open until it is actuated by the actuator 34A. When the exhaust throttle valve 30A closes, partially or completely, the exhaust gas F in the aftertreatment system 10 upstream of the exhaust throttle valve 30A is compressed, resulting in an increase in temperature of the exhaust gas F. Also, the resistance to pistons 42 requires a greater amount of fuel injection in the cylinders 44 to meet the engine 14 set point. The additional fuel injection creates additional heat energy in the exhaust gas F. The increased temperature of exhaust gas F upstream of the exhaust throttle valve 30A is transferred to the DPF 24 as the exhaust gas flows downstream to the DPF. The heated exhaust gas F provides sufficient heat to initiate regeneration (soot oxidation) at the DPF 24.

[0019] Referring now to FIG. 2, the exhaust throttle valve 30B and actuator 34B are located at an alternate location downstream of the DPF 24 on the second portion 26 of the exhaust pipe assembly. The exhaust throttle valve 30B is the same apparatus as described with respect to exhaust throttle valve 30A, operates in the same manner as exhaust throttle valve 30A, and is part of the same aftertreatment system 10 as the exhaust throttle valve 30A. The difference between the exhaust throttle valves 30A and 30B is the location on the aftertreatment system 10.

[0020] When the exhaust throttle valve 30B is actuated, the temperature of the exhaust gas F is higher on the upstream side of the butterfly valve 32B than on the downstream side. In the aftertreatment system of FIG. 2, the DPF 24 is subjected to the higher temperature exhaust gas F since the DPF is also located upstream of the exhaust throttle valve 30B. However, the DPF 24 is also subjected to higher pressure upstream of the exhaust throttle valve 30B.

[0021] Referring now to FIG. 3, it is also possible that the exhaust aftertreatment system 10 can include two exhaust throttle valves 30C, 30D having two actuators 34C, 34D. The exhaust throttle valves 30C, 30D are the same apparatus as described with respect to exhaust throttle valves 30A and 30B, they operate in the same manner as exhaust throttle valves 30A and 30B, and they are part of the same aftertreatment system 10 as the exhaust throttle valves 30A and 30B. The difference between the exhaust throttle valves 30A-30D are the locations on the aftertreatment system 10.

[0022] The first exhaust throttle valve 30C is disposed in upstream fluid communication from the DPF 24, and in downstream fluid communication from the engine 14 and exhaust manifold 28 on the fluid passageway 20. The second exhaust throttle valve 30D is disposed in downstream fluid communication from the DPF 24 on the fluid passageway 20. Similar to exhaust throttle valves 30A and 30B, the exhaust throttle valves 30C and 30D may be butterfly valves 32C, 32D, however other types of valves are possible.

[0023] It is possible that the exhaust throttle valves 30C, 30D can be actuated at the same time, or at different times, and with the same amount of passageway 20 obstruction, or with differing amounts of passageway obstruction. The exhaust throttle valves 30C, 30D are actuated with actuators 34C, 34D to optimize the pressure and the temperature between the valves and at the DPF 24 to effect regeneration of the DPF 24.

[0024] The actuation of the exhaust throttle valve 30A-30D, resulting in the regulation of the amount of exhaust gas flow F through the exhaust throttle valve, can be optimized for desired temperatures, pressures and engine loading. Additionally, the ECM 36 can monitor fuel delivery to the cylinders 44 and the engine speed/loading so that the engine speed/loading and exhaust gas temperature can be optimized for desired temperatures at the DPF 24 or anywhere on the aftertreatment system 10. It is possible that the exhaust aftertreatment system 10 may include a variable geometry turbocharger (not shown) to restrict exhaust gas flow F. It is also possible that the aftertreatment system 10 having exhaust throttle valves 30A-30D can be used on a vehicle having an exhaust brake (not shown) on the engine 14.

[0025] The aftertreatment system 10 having at least one exhaust throttle valve 30A-30D downstream of the exhaust manifold 28 allows the regeneration of the DPF 24 without significantly increasing the engine speed or loading. With the aftertreatment system 10 having the exhaust throttle valve 30A-30D downstream of the exhaust manifold 28, the vehicle can run on a “stop and drive” basis, where the engine 14 can be run at a lower speed and lower loading, while at the same time, providing exhaust gas flow F with a sufficiently high temperature to initiate the regeneration at the DPF 24.

What is claimed is:

1) An exhaust gas afttreatment system for a vehicle having an engine, the aftertreatment system comprising:
   a fluid passageway extending from the engine to an ambient for fluidly communicating exhaust gas;
a diesel particulate filter disposed on the fluid passageway downstream of the engine; and
at least one exhaust throttle valve located downstream of the engine on the fluid passageway, wherein actuation of the valve obstructs the flow of exhaust gas through the exhaust throttle valve and increases the temperature of the exhaust gas, wherein the heated exhaust gas affects regeneration at the diesel particulate filter.

2) The aftertreatment system of claim 1 further comprising an actuator for actuating the at least one exhaust throttle valve to at least partially obstruct the fluid passageway.

3) The aftertreatment system of claim 1 wherein the at least one exhaust throttle valve is a butterfly valve.

4) The aftertreatment system of claim 1 wherein the at least one exhaust throttle valve is disposed upstream of the diesel particulate filter on the fluid passageway.

5) The aftertreatment system of claim 1 wherein the at least one exhaust throttle valve is disposed downstream of the diesel particulate filter on the fluid passageway.

6) The aftertreatment system of claim 1 wherein the at least one exhaust throttle valve comprises two exhaust throttle valves, wherein a first exhaust throttle valve is disposed downstream of the diesel particulate filter on the fluid passageway, and a second exhaust throttle valve is disposed upstream of the diesel particulate filter on the fluid passageway.

7) The aftertreatment system of claim 1 further comprising at least one of a temperature sensor for sensing the temperature at the aftertreatment system and a back pressure sensor for sensing the pressure at the aftertreatment system, wherein at least one of the temperature sensor and the back pressure sensor communicate at least one of the temperature and the back pressure to an engine control module on the engine.

8) The aftertreatment system of claim 7 wherein when at least one of a predetermined amount of back pressure and a predetermined temperature is communicated to the engine control module, the engine control module actuates the at least one exhaust throttle valve.

9) The aftertreatment system of claim 1 wherein when the actuator is actuated, the engine injects additional fuel into a cylinder of the engine.

10) A method of regenerating an exhaust aftertreatment system of an engine having a diesel particulate filter, the method comprising:

   providing a fluid passageway from the engine to an ambient;
   providing an exhaust throttle valve downstream of the engine on the fluid passageway;
   actuating the exhaust throttle valve to at least partially obstruct the flow of exhaust gas through the fluid passageway;
   compressing and heating the exhaust gas upstream of the exhaust throttle valve on the fluid passageway; and
   delivering the heated exhaust gas to the diesel particulate filter to initiate regeneration.

11) The method of claim 11 further comprising the step of locating the exhaust throttle valve one of upstream of the diesel particulate filter and downstream of the diesel particulate filter.

12) The method of claim 11 wherein the exhaust throttle valve comprises two exhaust throttle valves, the method further comprising the step of locating a first exhaust throttle valve upstream of the diesel particulate filter and locating a second exhaust throttle valve downstream of the diesel particulate filter.

13) The method of claim 11 further comprising the step of sensing and communicating at least one of a back pressure of the aftertreatment system and a temperature of the aftertreatment system to an engine control module, and comparing at least one of the back pressure and the temperature to a predetermined back pressure and a predetermined temperature, wherein on the basis of the comparison, the engine control module actuates the exhaust throttle valve.

14) The method of claim 11 further comprising the step of actuating the exhaust throttle valve with an actuator.

15) The method of claim 11 further comprising the step of injecting an increased amount of fuel into the cylinders when the exhaust throttle valve is actuated.

16) An exhaust gas aftertreatment system for a vehicle having an engine, the aftertreatment system comprising:

   an engine control module associated with the engine;
   a fluid passageway extending from the engine to an ambient for fluidly communicating exhaust gas;
   a diesel particulate filter disposed on the fluid passageway downstream of the engine;
   at least one exhaust throttle valve located downstream of the diesel particulate filter on the fluid passageway;
   an actuator for actuating the at least one exhaust throttle valve; and
   at least one of a temperature sensor for sensing the temperature at the aftertreatment system and a back pressure sensor for sensing the pressure at the aftertreatment system, wherein at least one of the temperature sensor and the back pressure sensor communicate at least one of the temperature and the back pressure to an engine control module on the engine.

17) The exhaust gas aftertreatment system of claim 16 wherein when at least one of a predetermined amount of back pressure and a predetermined temperature is communicated to the engine control module, the engine control module actuates the at least one exhaust throttle valve with the actuator.

18) The exhaust gas aftertreatment system of claim 16 further comprising at least one second exhaust throttle valve located on the fluid passageway between the engine and the diesel particulate filter.

19) The exhaust gas aftertreatment system of claim 16 wherein the exhaust throttle valve is a butterfly valve.

20) The exhaust gas aftertreatment system of claim 16 wherein the exhaust throttle valve closes about 80 to 96% of the fluid passageway to obstruct the flow of exhaust gas through the exhaust throttle valve.

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