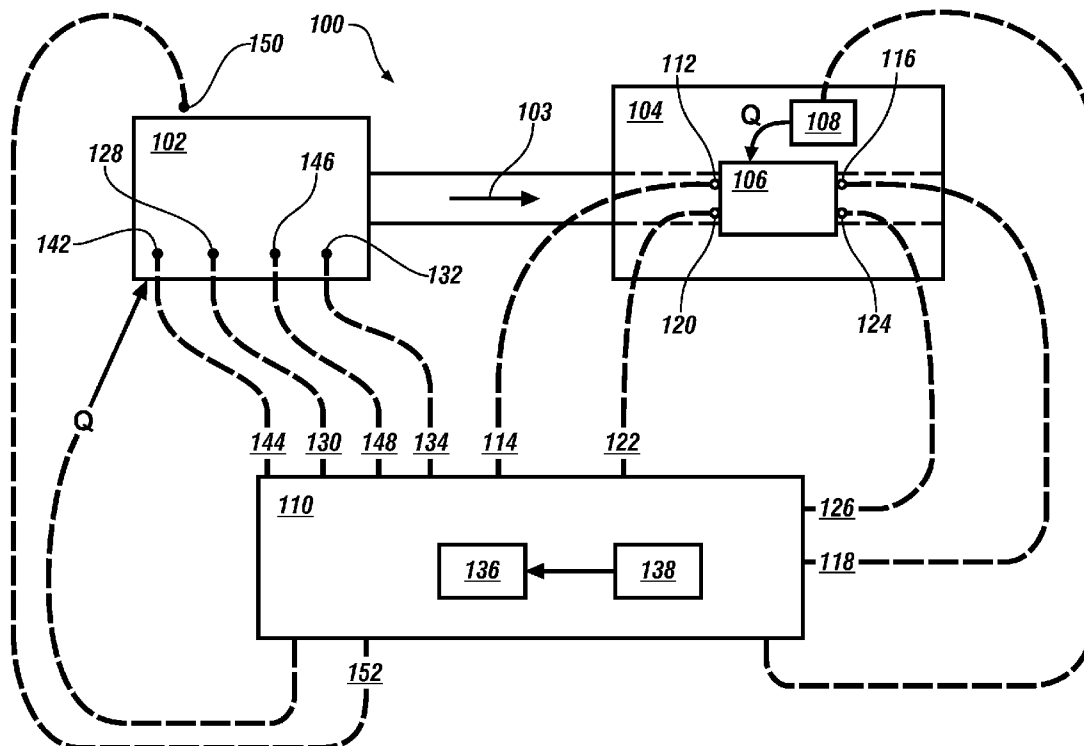




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Swoish et al.(10) **Pub. No.: US 2013/0298529 A1**(43) **Pub. Date: Nov. 14, 2013**(54) **SYSTEM AND METHOD FOR
CONTROLLING AN AFTER-TREATMENT
COMPONENT OF A
COMPRESSION-IGNITION ENGINE**(75) Inventors: **Christopher C. Swoish**, Lapeer, MI
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USPC **60/274; 60/295**(57) **ABSTRACT**

A method for controlling regeneration within an after-treatment component of an engine includes receiving a signal that is responsive to a change in pressure across an after-treatment component and calculating an estimate of accumulated particulate matter in the after-treatment component using a soot accumulation model calibrated to simulate operation of the engine at a reference condition. A soot model correction factor is based at least in part on an environmental temperature correction and is applied to the estimate of accumulated particulate matter in the after-treatment component to produce a temperature-compensated estimate of accumulated particulate matter in the after-treatment component. The temperature-compensated estimate of accumulated particulate matter in the after-treatment component is compared to a predetermined threshold associated with the after-treatment component, and a remedial action is initiated when the temperature-compensated estimate of accumulated particulate matter in the after-treatment component exceeds the predetermined threshold.



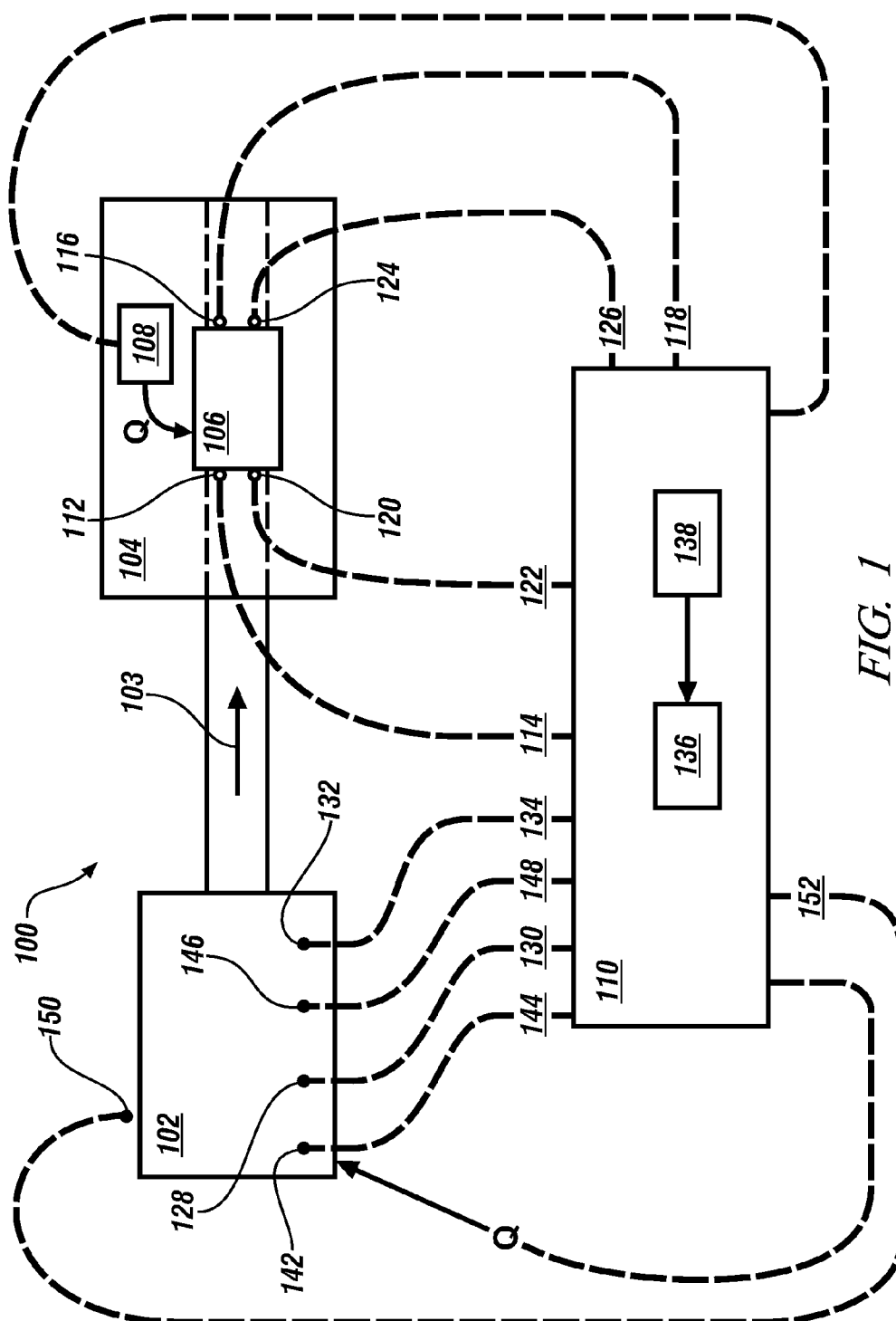
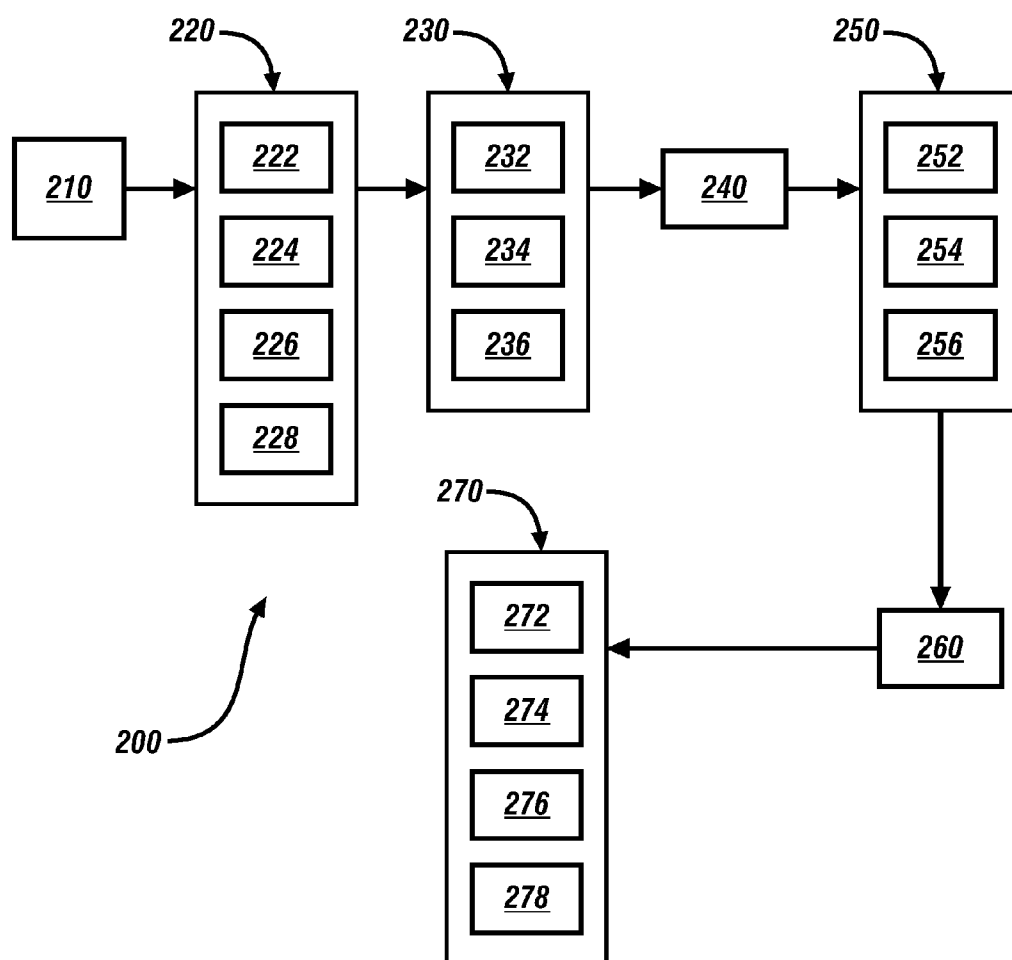


FIG. 1

*FIG. 2*

SYSTEM AND METHOD FOR CONTROLLING AN AFTER-TREATMENT COMPONENT OF A COMPRESSION-IGNITION ENGINE

FIELD OF THE INVENTION

[0001] The subject invention relates to after-treatment systems for compression-ignition engines and more particularly to a system and method for controlling an after-treatment component of a compression-ignition engine.

BACKGROUND

[0002] The emission of particulate matter in exhaust from compression-ignition engines is regulated for environmental reasons. Thus, vehicles equipped with compression-ignition engines often include after-treatment components such as particulate filters, catalyzed soot filters and adsorption catalysts for converting, reducing and/or removing particulate matter and other regulated constituents (e.g., nitrogen oxides or NOx) from their exhaust streams. Particulate filters, and other after-treatment components can be effective, but can also increase back pressure as they collect particulate matter.

[0003] Particulate matter may include ash and unburned carbon particles generally referred to as soot. As this carbon-based particulate matter accumulates in the after-treatment components, it can increase back pressure in the exhaust system. Engines that have large rates of particulate mass emission can develop excessive back pressure levels in a relatively short period of time, decreasing engine efficiency and power producing capacity. Therefore, it is desired to have particulate filtration systems that minimize back-pressure while effectively capturing particulate matter in the exhaust.

[0004] To accomplish both of these competing goals, after-treatment components must be regularly monitored and maintained either by replacing components or by removing the accumulated soot. Cleaning the accumulated soot from an after-treatment component can be achieved via oxidation to CO₂ (i.e., burning-off) and is known in the art as regeneration. To avoid service interruptions, regeneration is generally preferred over replacement of after-treatment components. A continuously regenerating trap (CRT) is an after-treatment component that traps particles in the exhaust stream and also includes a catalyst to aid in regeneration.

[0005] One way that regeneration may be accomplished is by increasing the temperatures of the filter material and/or the collected particulate matter to levels above the combustion temperature of the particulate matter. Elevating the temperature facilitates consumption of the soot by allowing the excess oxygen in the exhaust gas to oxidize the particulate matter. Particulate matter may also be oxidized, and thus removed, at lower temperatures by exposing the particulate matter to sufficient concentrations of nitrogen dioxide (NO₂). Exhaust from a compression-engine, such as a diesel engine, typically contains NOx, which consists primarily of nitric oxide (NO) and approximately 5 to 20 percent NO₂, with greater levels of NO₂ being common where oxidation catalysts are present in the exhaust stream. Thus, some level of regeneration occurs even at relatively low temperatures.

[0006] The regeneration process can be either passive or active. In passive systems, regeneration occurs whenever heat (e.g., carried by the exhaust gasses) and soot (e.g., trapped in the after-treatment components) are sufficient to facilitate oxidation, and/or whenever sufficient concentrations of NO₂

are present in the exhaust to enable oxidation at lower temperatures. In active systems, regeneration is induced at desired times by introducing heat from an outside source (e.g., an electrical heater, a fuel burner, a microwave heater, and/or from the engine itself, such as with a late in-cylinder injection or injection of fuel directly into the exhaust stream). Active regeneration can be initiated during various vehicle operations and exhaust conditions. Among these favorable operating conditions are stationary vehicle operations such as when the vehicle is at rest, for example, during a refueling stop. Engine control systems can be used to predict when it may be advantageous to actively facilitate a regeneration event and to effectuate control over the regeneration process.

[0007] An engine control system may use a soot model to deduce (i.e., predict) a mass of soot accumulated in the after-treatment component by monitoring properties of the exhaust stream as it flows through the after-treatment component. The control system can use the deduced soot mass data to monitor soot loading over time, to determine or anticipate when regeneration may be necessary or desirable, to facilitate a regeneration event, and/or to effectuate control over a regeneration process or other remedial measures. In one exemplary soot model, the pressure drop (i.e., decrease in pressure) across a loaded after-treatment component may be used, along with knowledge of the relationship between soot accumulation and pressure drop, to estimate the extent of soot loading in the after-treatment component. This is possible because, as soot accumulates in an after-treatment component, the pressure drop typically increases (at specific temperature and volumetric flow rates) from pressure drops experienced when the after-treatment component is clean.

[0008] It has been observed that changes in the temperature at which an engine operates can cause appreciable changes in quantities of soot carried in the engine exhaust stream. This may be due to a number of factors generally contributing to local combustion temperatures and control over the engine to compensate for temperature. As a result, problems have been encountered attempting to create soot models that can accurately predict soot emitted by the engine over a range of environmental temperatures.

[0009] Accordingly, it is desirable to provide an improved system and method for controlling an after-treatment component of a compression-ignition engine, for determining when to facilitate active regeneration, and for controlling active regeneration of particulate filtration systems, particularly having improved model accuracy over a range of environmental temperatures.

SUMMARY OF THE INVENTION

[0010] In one exemplary embodiment of the invention, a method for controlling regeneration within an after-treatment component of an engine includes receiving a signal that is responsive to a change in pressure across an after-treatment component and calculating an estimate of accumulated particulate matter in the after-treatment component using a soot accumulation model calibrated to simulate operation of the engine at a reference condition. A soot model correction factor is based, at least in part, on an environmental temperature correction and is applied to the estimate of accumulated particulate matter in the after-treatment component to produce a temperature-compensated estimate of accumulated particulate matter in the after-treatment component. The temperature-compensated estimate of accumulated particulate matter in the after-treatment component is compared to a

predetermined threshold associated with the after-treatment component, and a remedial action is initiated when the temperature-compensated estimate of accumulated particulate matter in the after-treatment component exceeds the predetermined threshold.

[0011] In another exemplary embodiment of the invention, a system for controlling regeneration within an after-treatment component of an engine comprises a regeneration controller configured to receive a signal that is responsive to a change in pressure across an after-treatment component and calculate an estimate of accumulated particulate matter in the after-treatment component using a soot accumulation model calibrated to simulate operation of the engine at a reference condition. The regeneration controller is configured to determine a soot model correction factor based at least in part on an environmental temperature correction and to apply the soot model correction factor to the estimate of accumulated particulate matter in the after-treatment component to produce a temperature-compensated estimate of accumulated particulate matter in the after-treatment component. The regeneration controller compares the temperature-compensated estimate of accumulated particulate matter in the after-treatment component to a predetermined threshold associated with the after-treatment component and initiates a remedial action when the temperature-compensated estimate of accumulated particulate matter in the after-treatment component exceeds the predetermined threshold.

[0012] The above features and advantages and other features and advantages of the invention are readily apparent from the following detailed description of the invention when taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Other 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:

[0014] FIG. 1 is a schematic diagram showing an exemplary system for controlling regeneration within an after-treatment component of a compression-ignition engine, and

[0015] FIG. 2 is a process flow diagram showing an exemplary process for controlling regeneration within an after-treatment component of a compression-ignition engine.

DESCRIPTION OF THE EMBODIMENTS

[0016] 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. As used herein, the term module refers to an application specific integrated circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and memory that executes one or more software or firmware programs, a combinational logic circuit, and/or other suitable components that provide the described functionality.

[0017] In accordance with an exemplary embodiment of the invention, as shown in FIG. 1, an exemplary system 100 for controlling regeneration within an after-treatment component of a compression-ignition engine includes a compression-ignition engine 102 of a vehicle (not shown). The compression-ignition engine 102 is coupled to an exhaust system 104, through which exhaust from engine 102 passes and is

treated before being discharged to the atmosphere. Exhaust system 104 is configured for the reduction of regulated exhaust gas constituents and thus includes at least one after-treatment component 106 such as a particulate filter for removing particulate matter and other regulated constituents from the exhaust stream. As can be appreciated, the after-treatment components, systems, models, and controls described herein can be implemented in various engine systems. Such engine systems may include, for example, but are not limited to, diesel engines, gasoline direct injection systems, and homogeneous charge compression ignition engine systems.

[0018] In an exemplary embodiment, the after-treatment component 106 is a continuously regenerating trap (CRT), which includes both an oxidation catalyst (OC) and a particulate filter. The OC of the CRT 106 may include, for example, a flow-through metal or ceramic monolith substrate. The substrate may be packaged in a shell or canister having an inlet for receiving exhaust from engine 102 and an outlet in fluid communication with the particulate filter of the CRT 106. The substrate 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 combination thereof. The OC treats unburned gaseous and non-volatile HC and CO, which are oxidized to form CO and H₂O.

[0019] The particulate filter portion of the after-treatment component 106 operates to filter the exhaust gas of carbon and other particulates. In various embodiments, the particulate filter portion of the after-treatment component 106 may be constructed using a wall flow monolith filter or other filter devices such as wound or packed fiber filters, open cell foams, sintered metal fibers, etc. The filter may be packaged in the shell or canister and may have an inlet in fluid communication with the OC and an outlet for discharging treated exhaust gas.

[0020] The accumulation of particulate matter within the particulate filter portion of the after-treatment component 106 is periodically cleaned, or regenerated. Regeneration involves the oxidation or burning of the accumulated carbon and other particulates in what is typically a high temperature (>600° C.) environment. The oxidation within the OC generates the high temperatures needed for regeneration.

[0021] As shown in FIG. 1, a heater 108 is configured for adding heat to the after-treatment component 106 to actively induce regeneration in the after-treatment component 106. A regeneration controller 110 is configured to predict when it may be necessary or advantageous to undergo regeneration in the after-treatment component and, when appropriate, to actively facilitate a regeneration event. The regeneration controller 110 may facilitate such an event, for example, by introducing heat to the after-treatment component 106 from an outside source such as the heater 108 or by causing injection of fuel into the engine 102 or the exhaust system 104.

[0022] To enable the regeneration controller 110 to better perform its functions, various instruments are positioned within the engine 102 and the exhaust system 104. The instruments are configured to be responsive to changes in relevant parameters in the engine 102 and the exhaust system 104 and to transmit signals to the regeneration controller 110 with the signals being indicative of operation of the engine 102 and the after-treatment component 104. For example, in an exemplary embodiment, an upstream pressure sensor 112 measures pressures of the exhaust stream upstream from the after-

treatment component 106 and produces upstream pressure signals 114. Similarly, a downstream pressure sensor 116 measures pressures of the exhaust stream downstream from the after-treatment component 106 and produces downstream pressure signals 118. In addition, an upstream temperature sensor 120 measures temperatures of the exhaust stream upstream from the after-treatment component 106 and produces upstream temperature signals 122.

[0023] A downstream temperature sensor 124 measures temperatures of the exhaust stream downstream from the after-treatment component 106 and produces downstream temperature signals 126. An engine speed sensor 128 senses speeds of the engine 102 and produces engine speed signals 130. An engine flow sensor 132 senses mass flow rates of working fluid (e.g., air or air and fuel or exhaust gas) flowing in the engine 102 or exhaust system 104 and produces engine flow rate signals 134. An engine intake air temperature sensor 142 senses a temperature of combustion air entering the engine 102 and produces intake air temperature signals 144. A downstream charge air cooler temperature sensor 146 senses a temperature of combustion air downstream from a charge air cooler associated with the stream of combustion air entering the engine 102 and produces a charge air temperature signal 148. An environmental temperature sensor 150 senses a temperature of the ambient environment in which engine 102 operates and produces an environmental temperature signal 152.

[0024] The regeneration controller 110 receives information, such as one or more of the upstream pressure signals 114, downstream pressure signals 118, upstream temperature signals 122, downstream temperature signals 126, engine speed signals 130, engine flow rate signals 134, intake air temperature signals 144, charge air temperature signals 148, and environmental temperature signals 152 from the upstream pressure sensor 112, the downstream pressure sensor 116, the upstream temperature sensor 120, the downstream temperature sensor 124, the engine speed sensor 128, the engine flow sensor 132, the engine intake air temperature sensor 142, the downstream charge air cooler temperature sensor 146, and the environmental temperature sensor 150. A processor 136 of the regeneration controller 110 cooperates with a memory 138 associated with the regeneration controller 110 to execute instructions that are configured to enable the regeneration controller 110 to monitor soot loading in the after-treatment component 106, to determine or anticipate when regeneration in the after-treatment component 106 may be necessary or desirable, to facilitate a regeneration event in the after-treatment component 106, and/or to effectuate control over a regeneration process or other remedial measures.

[0025] For example, in an exemplary embodiment, a regeneration controller 110 is configured to estimate a quantity of particulate matter accumulation in the after-treatment component 106 based on a pressure drop index that is indicative of a decrease in pressure of the exhaust stream as it passes through the after-treatment component 106. In an exemplary embodiment, the regeneration controller 110 uses the upstream pressure signals 114 and the downstream pressure signals 118 to compute the pressure drop index. In addition, the regeneration controller 110 uses the engine flow rate signals 134 or the engine speed signals from the engine speed sensor 128 or the engine flow sensor 132 to generate a flow rate index.

[0026] Once the properties of the flow stream have been generated, the regeneration controller 110 estimates a quan-

tity of particulate matter accumulation in the after-treatment component 106. In an exemplary embodiment, the regeneration controller 110 uses a soot accumulation model based on soot rate maps developed using engine-out conditions. In another exemplary embodiment, the regeneration controller 110 uses a soot accumulation model based on the relationship between the pressure drop index, the flow rate index, and the temperature index. As one skilled in the art will appreciate, increases in the amount of pressure drop (i.e., decrease in pressure) at a constant flow rate and temperature is indicative of accumulation of soot or other particulate matter in the after-treatment component 106. Those skilled in the art will also appreciate that the flow rate index may be normalized to a standardized temperature and a standardized pressure (e.g., according to the ideal gas law) so as to eliminate some or all of the inaccuracies associated with changes in temperature and pressure of the exhaust stream. This is possible because it is known that a consistent relationship may exist between pressure loss and such a corrected flow rate even though temperature and/or pressure of the flow may change.

[0027] As mentioned above, it has been recognized that the temperature of the environment in which the engine 102 operates can cause appreciable changes in quantities of soot carried in the engine exhaust stream. To enable the soot model to compensate for the effects of environmental temperature, a temperature correction factor is applied to the output predictions produced by the soot model. To determine the temperature correction factor, a choice is first made regarding which environmental temperature parameter to use as a basis of the correction. In an exemplary embodiment, a hierarchy is pre-established. In another exemplary embodiment, a user selects which parameter to use. In yet another embodiment, the sensed environmental temperatures are evaluated for reliability, and the most reliable parameter is used. This may result in the use of the intake air temperature signals 144, the charge air temperature signals 148, or the environmental temperature signals 152.

[0028] Once the appropriate temperature signal is selected, the correction factor is determined based on the selected temperature and a known or predicted relationship between the temperature and the correction factor. In an exemplary embodiment, multiple correction curves may be used to determine the correction factor at different ambient elevations, such as sea level, medium elevation, and high elevation. The result is multiple temperature correction factors across a range of reference elevations. The correction factor associated with the actual elevation may then be determined, for example, by interpolation. The actual elevation may be determined by the ambient pressure. Finally, the correction factor may be applied so as to adjust the output from the soot model to compensate for ambient temperature.

[0029] It should be appreciated that a number of expressions exist for quantifying and tracking pressure drop in an after-treatment component. For example, in one embodiment, the pressure drop index is calculated as a ratio of upstream pressure to downstream pressure (i.e., $PR = P_u/P_d$) so as to represent a pressure ratio across the after-treatment component. In another embodiment, the pressure drop index is calculated as a difference between the upstream pressure and the downstream pressure (i.e., $DP = P_u - P_d$) so as to represent a difference in pressure across the after-treatment component. In still another embodiment, the pressure drop index is calculated as the difference between the upstream pressure and the downstream pressure, with the difference divided by the

magnitude of the upstream pressure (i.e., as a normalized pressure drop, $DPP=DP/P_u$) so as to represent a normalized difference in pressure across the after-treatment component. As those skilled in the art will appreciate, the above-described flow rate index signal can be produced by an engine speed sensor or a mass airflow sensor or any other sensor configured to sense an engine operating condition that is indicative of the relative flow rate of the exhaust stream.

[0030] When a pressure-based soot accumulation model is to be executed or relied upon for soot estimation, the regeneration controller **110** may estimate the accumulated particulate matter in the after-treatment component based, at least in part, on a soot accumulation model. As described above, the model may require knowledge of the pressures, temperatures, and flow rates of the exhaust stream as described above. In an exemplary embodiment, the estimate produced by the model represents the amount of particulate matter that is predicted to have accumulated in the after-treatment component. The pressure-based soot accumulation model, which may be based on empirical data, is configured to reflect the relationship between the amount of particulate matter that has accumulated in the after-treatment component, the pressure drop index, the flow index, and the temperature index—at a reference ambient temperature (i.e., a standardized output). As discussed above, the standardized output from the pressure-based soot accumulation model is scaled according to the temperature correction factor so as to predict the amount of particulate matter that has accumulated in the after-treatment component for the particular ambient temperature at which the engine **102** is operating.

[0031] Since the estimate of matter accumulated in the after-treatment component is to be compared to a predetermined threshold associated with the after-treatment component, and since a remedial action may be facilitated when the adjusted estimate of accumulated particulate matter in the after-treatment component exceeds the predetermined threshold, inaccuracies in the process would have the potential to trigger regeneration processes unnecessarily or late. Therefore, by applying a temperature compensation factor as described above, the regeneration controller **110** may improve reliability of the estimated level of soot accumulation, thereby reducing the need for excessive margins and potentially eliminating unnecessary service.

[0032] In accordance with an exemplary embodiment of the invention, as shown in FIG. 2, an exemplary process **200** for controlling regeneration within an after-treatment component of a compression-ignition engine, such as a CRT, generally includes the step of receiving one or more values of one or more parameters associated with an exhaust stream passing through the after-treatment component (step **210**). In an exemplary embodiment, the parameter may represent upstream pressure, downstream pressure, change in pressure across the after-treatment component, upstream temperature, downstream temperature, engine speed, or engine flow rate.

[0033] The value may be received as a signal from the upstream pressure sensor **112**, the downstream pressure sensor **116**, the upstream temperature sensor **120**, the downstream temperature sensor **124**, the engine speed sensor **128**, or the engine flow sensor **132**, or a combination based thereon. The parameter may be a pressure drop index indicative of a decrease in pressure of an exhaust stream as it passes through the after-treatment component, a flow rate index

indicative of a rate of flow of the exhaust stream, and/or a temperature index indicative of a temperature of the exhaust stream.

[0034] In addition to receiving one or more values, the process **200** includes determining an environmental temperature under which the engine is operating (step **220**). More specifically, this step of the process includes: (a) receiving an intake air temperature signal (step **222**); (b) receiving a charge air temperature signal (step **224**); (c) receiving an environmental (e.g., ambient) temperature signal (step **226**); and (d) determining an environmental temperature correction to be used for soot model correction purposes (step **228**). The determination of the environmental temperature correction may be based on a user prescribed selection or a predefined algorithm (e.g., a hierarchy or an assessment of reliability) resulting in a selection based on at least one of the intake air temperature signal, the charge air temperature signal, or the environmental temperature signal.

[0035] Based on the environmental temperature correction determined for soot model correction purposes, the regeneration controller **110** determines a soot model correction factor for use in adjusting the output of the soot model for the environmental temperature (step **230**). In an exemplary embodiment, the regeneration controller **110** determines an elevation at which the engine is operating based on a pressure signal such as an intake pressure signal (step **232**). Next, the regeneration controller **110** reads one or more maps (with each map representing an elevation at or near where the engine is determined to be operating, such as at sea level, a mid elevation such as 5000 ft above sea level, and/or a high elevation such as 10,000 feet above sea level) to determine the soot model correction factors for the various elevations at the particular environmental temperature correction (step **234**). In addition, the regeneration controller **110** may use the actual operating elevation to interpolate between the soot model correction factors associated with the various elevations, thereby determining the appropriate soot model correction at the particular environmental temperature correction and operating elevation (step **236**). Still further, the regeneration controller **110** may facilitate the setting and adjustment of limits on the environmental temperature or operating elevation, outside of which the pressure-based soot accumulation model may be deemed unreliable or unsuitable for reliable adjustment from the reference conditions at which the model was developed or calibrated (step **240**).

[0036] The regeneration controller **110** may rely upon a soot estimation technique, such as a soot accumulation model based on pressure drop, to calculate an estimate of accumulated particulate matter in the after-treatment component (step **250**). In one embodiment, this calculation is based, at least in part, on a soot accumulation model that is developed and/or calibrated at a reference condition (e.g., sea level elevation, ICAO standard ambient temperature). The calculation relies upon values for pressure drop index, flow rate index, temperature index, and the appropriate soot model correction at the particular environmental temperature correction and operating elevation. The estimate of accumulated particulate matter in the after-treatment component is then compared to one or more predetermined thresholds associated with the after-treatment component (step **260**). A remedial action is initiated when the adjusted estimate of accumulated particulate matter in the after-treatment component exceeds the predetermined threshold (step **270**).

[0037] In an exemplary embodiment, the step of estimating the quantity of accumulated particulate matter in the after-treatment component (step 250) begins with the calculation or receipt of a pressure drop index indicative of a decrease in pressure of an exhaust stream as it passes through the after-treatment component (step 252). In an exemplary embodiment, the pressure drop index is indicative of the level of pressure decrease experienced by the exhaust stream as it passes through the after-treatment component. In one embodiment, the pressure drop index is calculated as a ratio of upstream to downstream pressure (i.e., $PR = P_u/P_d$) so as to represent a pressure ratio across the after-treatment component.

[0038] In another embodiment, the pressure drop index is calculated as a difference between the upstream and downstream pressures (i.e., $DP = P_u - P_d$) so as to represent a difference in pressure across the after-treatment component. In still another embodiment, the pressure drop index is calculated as the difference between the upstream and downstream pressures divided by the magnitude of the upstream pressure (i.e., as a normalized pressure drop, $DPP = DP/P_u$) so as to represent a normalized difference in pressure across the after-treatment component. An exemplary step of estimating the quantity of accumulated particulate matter in the after-treatment component (step 250) also includes determining a flow rate index that is indicative of a relative flow rate of the exhaust stream (step 254). The flow rate index signal can be produced by an engine speed sensor or a mass airflow sensor or any other sensor configured to sense an engine operating condition that is indicative of the relative flow rate of the exhaust stream.

[0039] Once the pressure drop index and the flow index of the exhaust stream have been determined, an exemplary step of estimating the quantity of accumulated particulate matter in the after-treatment component (step 250) employs a pressure-based soot accumulation model (step 256) to estimate the accumulated particulate matter in the after-treatment component based on the pressure drop index and the flow rate index. As discussed above, the soot model may be developed or calibrated so as to correspond to a reference condition, while adjustment to the actual environmental conditions (elevation and temperature) is accomplished by application of the appropriate soot model correction at the particular environmental temperature correction and operating elevation, which the regeneration controller 110 developed based on the selected temperature (step 230).

[0040] Thus, an estimate is produced representing an amount of particulate matter that is predicted to have accumulated in the after-treatment component. The pressure-based soot accumulation model, which may be based on empirical data, is configured to reflect the relationship between the amount of particulate matter that has accumulated in the after-treatment component, the pressure drop index, the flow index, and the particular environmental condition under which the engine is (or has been) operating. Other techniques may reflect other relationships and may be similarly correlated to observed data.

[0041] In an exemplary embodiment, the step of initiating a remedial action (step 270) comprises adjusting one or more engine control parameters so as to modify operation of the engine to promote passive regeneration in the after-treatment component (step 272). For example, the one or more adjustments may be configured to provide a minimum temperature at the after-treatment component promoting passive regen-

eration in the after-treatment component. Alternatively the one or more adjustments may comprise modifying fueling and timing of the engine (step 274) or activating an auxiliary heating element to increase a temperature of the exhaust stream (step 276) or activating a warning light instructing the operator to initiate regeneration in (or replacement of) the after-treatment component (step 278).

[0042] 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 application.

What is claimed is:

1. A method for controlling regeneration within an after-treatment component of an engine, comprising:
 - receiving a signal that is responsive to a change in pressure across an after-treatment component;
 - calculating an estimate of accumulated particulate matter in the after-treatment component using a soot accumulation model calibrated to simulate operation of the engine at a reference condition;
 - determining a soot model correction factor based at least in part on an environmental temperature correction;
 - applying the soot model correction factor to the estimate of accumulated particulate matter in the after-treatment component to produce a temperature-compensated estimate of accumulated particulate matter in the after-treatment component;
 - comparing the temperature-compensated estimate of accumulated particulate matter in the after-treatment component to a predetermined threshold associated with the after-treatment component; and
 - initiating a remedial action when the temperature-compensated estimate of accumulated particulate matter in the after-treatment component exceeds the predetermined threshold.
2. The method of claim 1, wherein the environmental temperature correction is based on an intake air temperature signal.
3. The method of claim 1, wherein the environmental temperature correction is based on a charge air temperature signal.
4. The method of claim 1, wherein the environmental temperature correction is based on an ambient temperature signal.
5. The method of claim 1, wherein the soot model correction factor is determined by interpolating between soot model correction factors associated with various elevations, thereby determining the appropriate soot model correction at the particular environmental temperature correction and operating elevation.
6. The method of claim 1, wherein the soot accumulation model is based on a pressure drop index indicative of a decrease in pressure of an exhaust stream as it passes through the after-treatment component.
7. The method of claim 6, wherein the pressure drop index represents a pressure ratio across the after-treatment component.

8. The method of claim 1, wherein the soot accumulation model is based on a flow rate index indicative of a rate of flow of the exhaust stream.

9. The method of claim 8, wherein the flow rate index is based on a speed of the engine.

10. The method of claim 1, wherein the soot accumulation model is based on a relationship between a pressure drop index indicative of a decrease in pressure of an exhaust stream as it passes through the after-treatment component and a flow rate index indicative of a rate of flow of the exhaust stream.

11. The method of claim 1, wherein initiating a remedial action comprises adjusting one or more engine control parameters so as to modify operation of the engine to promote passive regeneration in the after-treatment component.

12. The method of claim 11, wherein said adjusting is configured to provide a minimum temperature at the after-treatment component to promote regeneration in the after-treatment component.

13. The method of claim 11, wherein said adjusting comprises modifying fueling and timing of the engine.

14. The method of claim 11, wherein said adjusting comprises activating an auxiliary heating element to increase a temperature of the exhaust stream.

15. The method of claim 11, wherein the remedial action comprises activating a warning light instructing an operator to initiate regeneration in the after-treatment component.

16. A system for controlling regeneration within an after-treatment component of an engine comprising:

a regeneration controller having a processor coupled to a memory storage device, the regeneration controller being configured to:

receive a signal that is responsive to a change in pressure across an after-treatment component;
calculate an estimate of accumulated particulate matter in the after-treatment component using a soot accu-

mulation model calibrated to simulate operation of the engine at a reference condition;

determine a soot model correction factor based at least in part on an environmental temperature correction;

apply the soot model correction factor to the estimate of accumulated particulate matter in the after-treatment component to produce a temperature-compensated estimate of accumulated particulate matter in the after-treatment component;

compare the temperature-compensated estimate of accumulated particulate matter in the after-treatment component to a predetermined threshold associated with the after-treatment component; and

initiate a remedial action when the temperature-compensated estimate of accumulated particulate matter in the after-treatment component exceeds the predetermined threshold.

17. The method of claim 16, wherein the environmental temperature correction is based on an intake air temperature signal.

18. The method of claim 16, wherein the environmental temperature correction is based on a charge air temperature signal.

19. The method of claim 16, wherein the environmental temperature correction is based on an ambient temperature signal.

20. The method of claim 16, wherein the soot model correction factor is determined by interpolating between soot model correction factors associated with various elevations, thereby determining the appropriate soot model correction at the particular environmental temperature correction and operating elevation.

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