US 20080163610A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2008/0163610 A1**

(43) **Pub. Date: Jul. 10, 2008**

Baird et al.

(54) **METHOD AND SYSTEM FOR REGENERATING EXHAUST SYSTEM FILTERING AND CATALYST COMPONENTS USING VARIABLE HIGH ENGINE IDLE**

(76) Inventors: **Matthew Thomas Baird**, Canton, MI (US); **Jason Thomas Barton**, Canton, MI (US)

Correspondence Address:
RADER, FISHMAN & GRAUER PLLC
39533 WOODWARD AVENUE, SUITE 140
BLOOMFIELD HILLS, MI 48304-0610

(21) Appl. No.: **11/650,084**

(22) Filed: **Jan. 5, 2007**

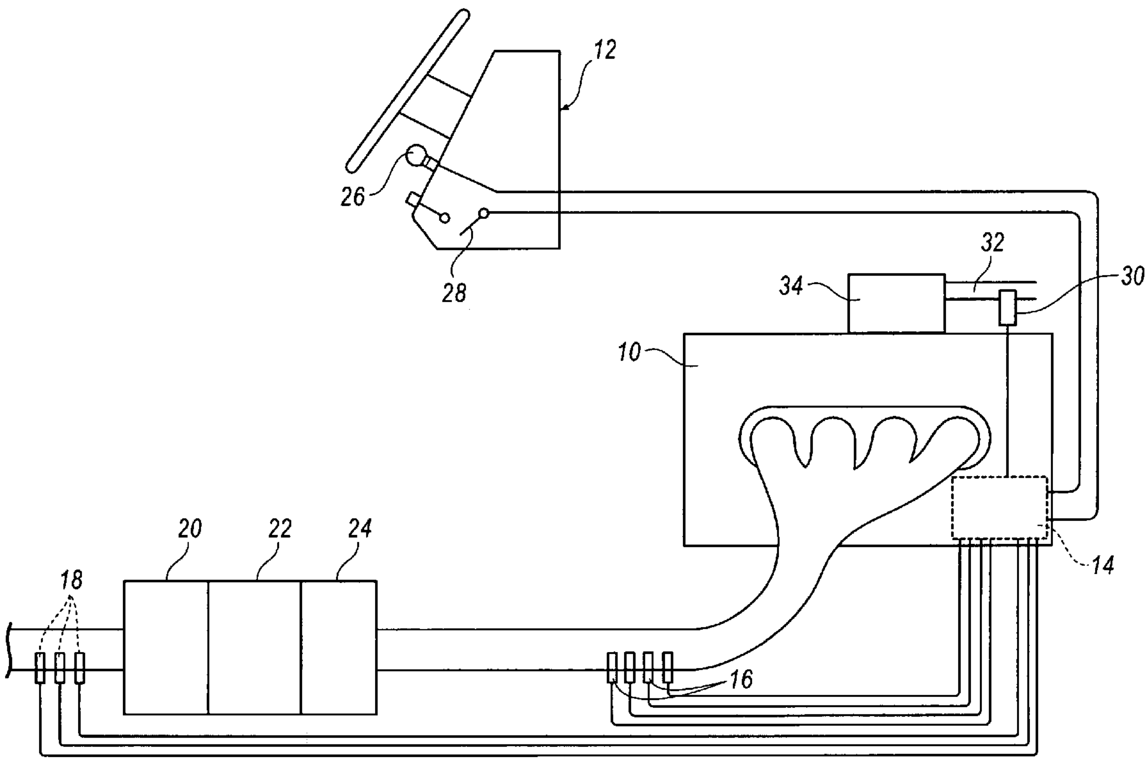
Publication Classification

(51) **Int. Cl.**
F01N 3/023 (2006.01)

(52) **U.S. Cl.** **60/295**; 60/286

(57) **ABSTRACT**

A method and system for regenerating particulate filters, catalyzed soot filters, and NOx adsorber catalysts for a vehicle having a compression ignition engine.



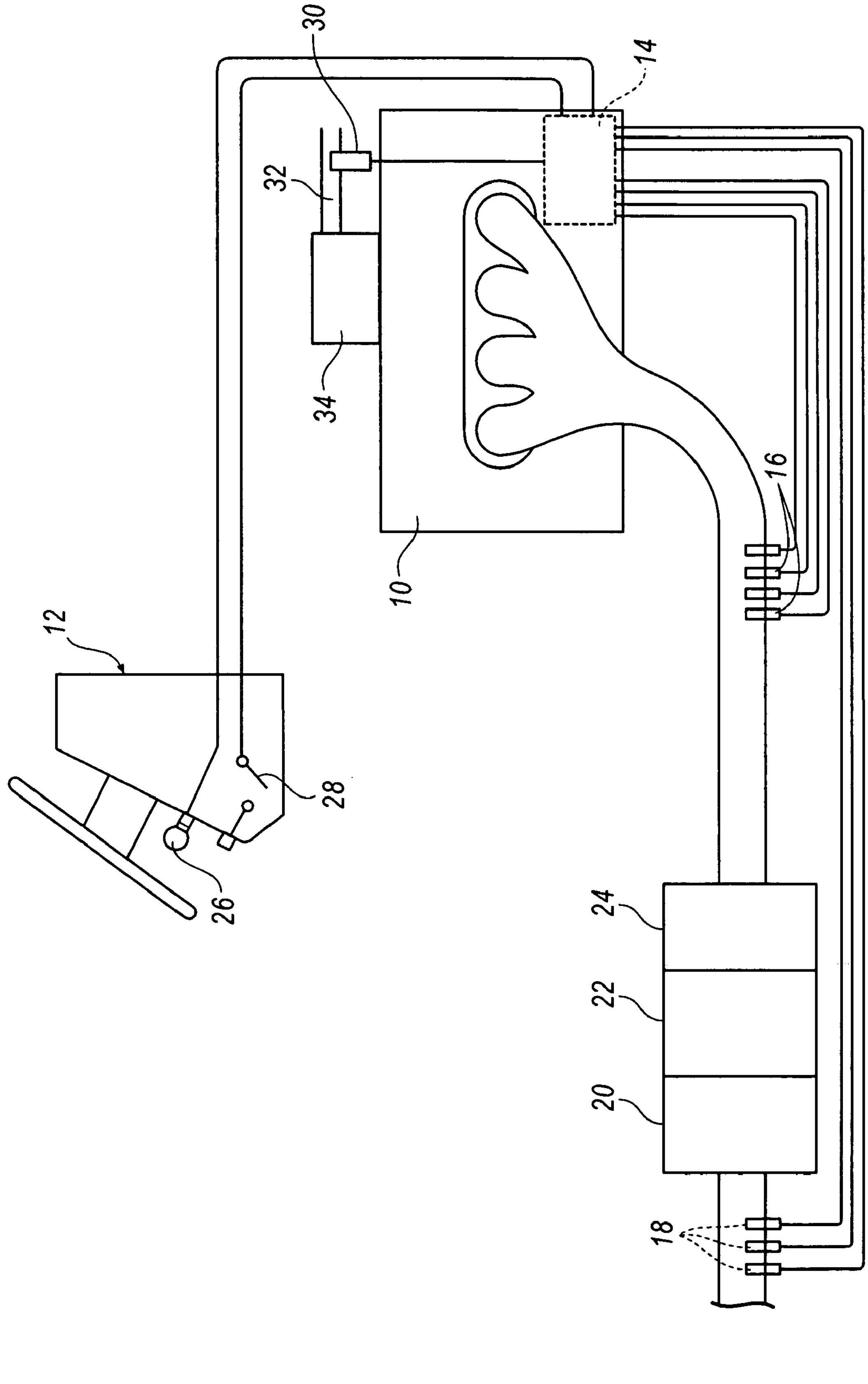


FIG. 1

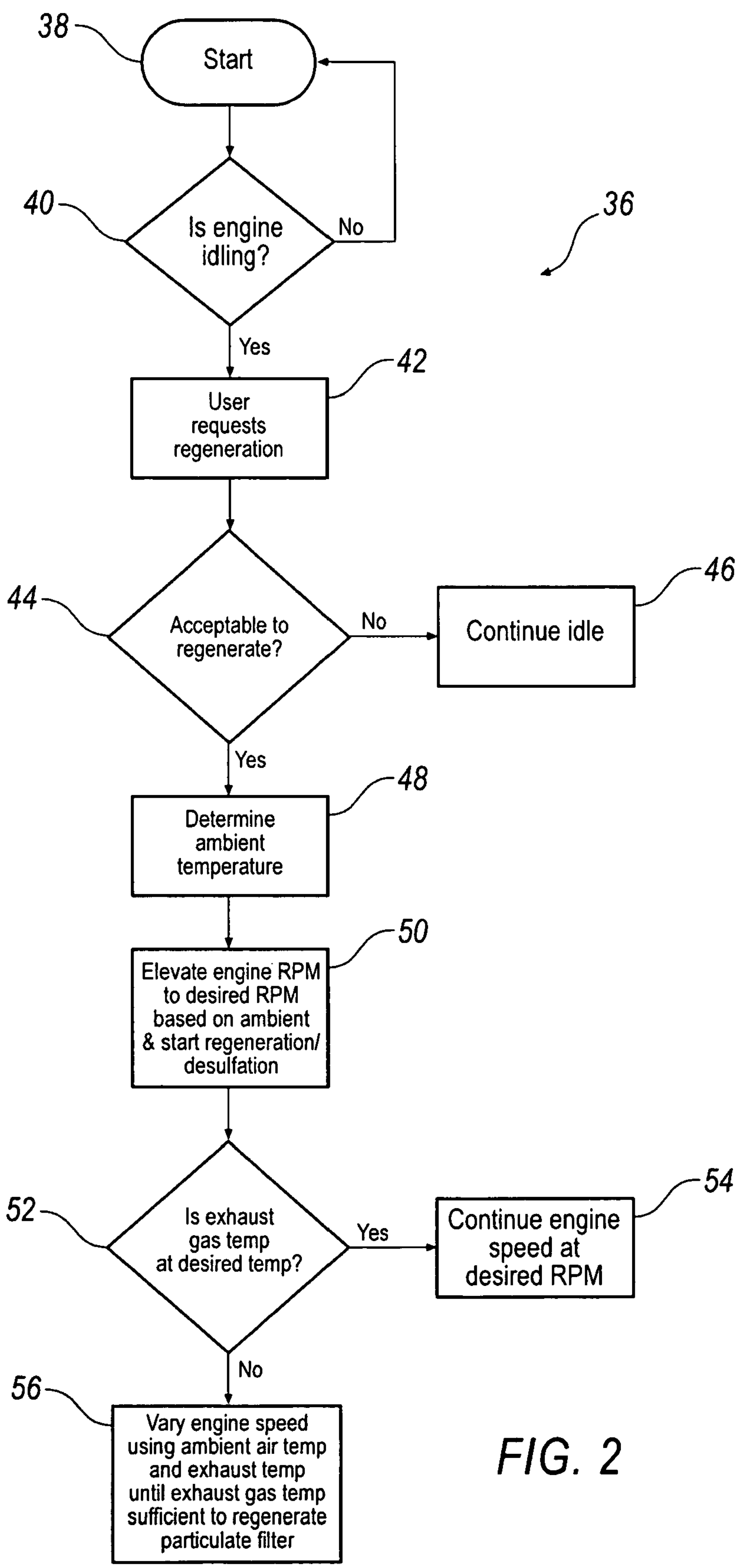

38
Start
40
Is engine idling?
No
Yes
36
42
User requests regeneration
44
Acceptable to regenerate?
No
46
Continue idle
Yes
48
Determine ambient temperature
50
Elevate engine RPM to desired RPM based on ambient & start regeneration/ desulfation
52
Is exhaust gas temp at desired temp?
Yes
54
Continue engine speed at desired RPM
No
56
Vary engine speed using ambient air temp and exhaust temp until exhaust gas temp sufficient to regenerate particulate filter

FIG. 2

METHOD AND SYSTEM FOR REGENERATING EXHAUST SYSTEM FILTERING AND CATALYST COMPONENTS USING VARIABLE HIGH ENGINE IDLE

FIELD OF THE INVENTION

[0001] The present invention relates to a system and method of regenerating particulate diesel engine exhaust filters.

[0002] The present invention relates to a system and method of regenerating diesel engine exhaust system particulate filters and catalysts.

[0003] The present invention further relates to a system and method of regenerating diesel engine exhaust system particulate filters and catalysts, as well as catalyzed and uncatalyzed cordierite, silicon carbide and sintered and unsintered substrates.

[0004] The present invention further relates to a system and method of regenerating diesel engine exhaust system particulate filters and catalysts, as well as catalyzed and uncatalyzed cordierite, silicon carbide and sintered and unsintered substrates while running the diesel engine at lower rpms to save on fuel costs and reduce noise.

BACKGROUND

[0005] Diesel engine exhaust systems include particulate filters, catalyst soot filters, NOx adsorber catalysts, and selective catalytic reduction (SCR) systems that clean exhaust and reduce engine emissions. There is a need in the particulate filter aspects of the exhaust system to oxidize the carbon particulate soot captured by the filter. With regard to catalyst soot filters, NOx adsorber catalysts, and SCRs, there is a need to regenerate and desulfate exhaust system components on a regular basis for efficient operation.

[0006] Regeneration of diesel particulate filters requires heating the filters to temperatures of approximately 500° C. to 650° C. for a period range of about 10 to 60 minutes, depending upon the soot quantity within the diesel particulate filter. Regeneration of catalyzed soot filters requires heating the filters to temperatures of approximately 400° C. for a period of about 10 minutes. Desulfation of NOx adsorbers requires heating the catalysts to temperatures of approximately 700° C. for at least 5 minutes while operating the engine with a rich air/fuel mixture (excess fuel/no excess oxygen), that produces exhaust gas with higher concentrations of unburned hydrocarbons and carbon monoxide, and no oxygen. The prior art has proposed maintaining high catalyst temperatures by locating the catalyst components close to the engine turbocharger turbine outlet. This approach is not practical in on-highway vehicles due to space constraints.

[0007] One preferred way to perform a regeneration cycle is to use the engine operation heat and the exhaust temperature during normal duty cycles of the engine operation, such as over the road operation of the engine, to heat the filter and catalyst components during the on road duty cycle to regenerate the diesel engine particulate filters, NOx adsorbers catalysts, SCRs and other exhaust system components that require regeneration or desulfation.

[0008] Given certain duty cycles where over the road regeneration of the diesel engine particulate filter, NOx adsorber catalysts, SCR's, catalyzed and uncatalyzed silicon carbide, and sintered and unsintered substrates in an exhaust system is not possible, the operator must perform a stationary parked regeneration so that the soot can be oxidized within the operator's diesel particulate filer. One way to perform such a regeneration cycle is to heat the filter and catalyst components while the vehicle is at rest, for example, during a refueling stop or an overnight stop. High exhaust temperatures are most effectively generated by loading the engine, however, it is difficult to adequately load an engine while a vehicle is at rest. The only loads on the engine when a vehicle is at rest are electrical loads such as those associated with lights and air conditioning systems and mechanical loads related to the operation of an air compressor, cooling fan and the idling torque load of the engine. These loads are negligible compared to the road loads encountered when a loaded vehicle is climbing a grade.

[0009] There is a need for an effective system for producing higher temperatures needed for regenerating exhaust system particulate filter and catalyst components without unduly penalizing fuel economy.

[0010] These and other problems are addressed by applicant's invention and summarized below.

SUMMARY OF THE INVENTION

[0011] According to one aspect of the present invention, a system for regenerating particulate filters and catalyst soot filters is provided for compression ignition engines. The system includes an integrated assembly comprising a starter, an alternator, a flywheel and a retarder. An engine control module is adapted to receive a signal for initiating a regeneration cycle when the vehicle is at rest and the engine is idling. In response to receiving the signal to initiate a regeneration cycle, the control module. The engine control module also adjusts engine operating parameters.

[0012] The system also includes a sensor for sensing the temperature of the exhaust. When the sensor generates a signal indicating that the exhaust temperature is insufficient for regeneration, raises the temperature of the exhaust and also increases the load on the engine. When the engine control module (ECM) receives a request for a high idle regeneration, the ECM immediately activates the engine fan to increase load on the engine and it immediately ramps up to an elevated rpm. In this regard, the fan is activated as a function of exhaust temperature. When a need for an increased load is sensed, the ECM activates the fan, and when the need for increased load is not sensed, the fan is not activated. Thus, the fan activation can be a function of load and exhaust temperature, and approximated ambient air temperature, and activating the fan induces a higher exhaust temperature and this is a more effective way of converting hydrocarbon across the Diesel Oxidation Catalyst (DOC). Upon reaching the elevated rpm operation, the ECM will wait for an acceptable temperature before initiating thermal management mode to avoid potential white smoke issues. Thermal Management Mode (TMM) raises the exhaust temperature up to an acceptable temperature where hydrocarbon can be converted across the DOC effectively.

[0013] Preferably, the signal to initiate a regeneration cycle for a filter may be generated by a sensor that monitors particulate load on the filters and engine operating history to determine when regeneration of the diesel particulate filter is required. Thus, the initial signal to regenerate the diesel engine particulate filter occurs automatically without any operator input or knowledge.

[0014] In another embodiment, if regeneration cycle cannot be accomplished in normal operating cycle of the engine, or regeneration of the filter cannot occur automatically, a warning light may be activated alerting the operator that a stationary parked regeneration or a high idle regeneration cycle is required. If the operator ignores the warning light, the ECM may activate any combination of engine derate, or the check engine light, or the stop engine light or shut down the engine to protect the filter.

[0015] The signal to initiate a desulfation cycle of a NOx adsorber catalyst is initiated in response to signals received from exhaust NOx sensors, temperature sensors, and air/fuel ratio sensors that are monitored by the engine control module during the desulfation cycle of a NOx adsorber catalyst. Fueling and timing engine operating parameters can be adjusted by the engine control module for desulfation and regeneration.

[0016] Referring to another aspect of the invention, a method of regenerating particulate filters, catalyzed soot filters and NOx adsorber catalysts for a vehicle having a compression ignition engine is provided. The compression ignition engine has an engine control module and an integrated starter/alternator/flywheel/retarder. The method comprises sensing the condition of the particulate filter, catalyzed soot filters, and NOx adsorber catalysts and generating an initiate cleaning cycle signal upon sensing that the filters or the catalysts require a parked regeneration. Operation of the engine and the vehicle are monitored to determine whether the engine is idling and whether the vehicle is stopped, whereupon an engine idling/vehicle stop signal is generated. Upon receiving the initiate cleaning engine cycle signal and the engine idling/vehicle stop signal, the engine control module adjusts engine control parameters to bring the engine to a specified operating speed. The physical temperature on the air intake tubing of the vehicle before the inlet to the air compressor of the turbocharger is also sensed. The ECM uses the ambient air temperature to estimate at what engine speed the parked regeneration cycle should be performed. If the current engine speed is not successful at creating an exhaust temperature at a required elevated temperature to convert hydrocarbon across the DOC, then the controller can elevate the engine speed further so that the appropriate elevated exhaust temperature can be achieved. In addition, if the temperature is too high, the ECM can lower engine rpm if needed to save fuel.

[0017] Upon sensing that the exhaust gas temperature is insufficient for the regeneration of filters, a low temperature signal is generated. When the engine control module receives such a low temperature signal, the physical temperature on the air intake tubing of the vehicle before the inlet to the compressor to the air turbocharger is sensed. Fueling strategies are provided in a data look up table in the engine control module based upon the temperature of the ambient air entering the compressor. The lower the sensed temperature of the ambient air, the more fuel is allowed to the engine, thereby causing the engine speed to increase. The increase in engine speed increases the heat of the exhaust gas stream which passes over the filter, cleaning the soot and particulates. Once the filter is clean, the engine control module senses the condition by a pressure sensor. When fuel is being dosed and oxidized across the DOC, soot in the filter burns as a result of elevated temperatures. In addition, the ECM contains data that approximates how much soot is burned from the particulate filter based upon the exhaust gas temperature and the engine air to fuel ratio at the current engine operating condition, and, if the amount of soot burned approximates the amount of soot that should have been burned, fueling is reduced and the process is completed.

[0018] According to other aspects of the method of the present invention, a signal to initiate a regeneration cycle is generated by a sensor that monitors exhaust gas for soot and particulates and compares that amount to trigger thresholds in an internal table within the ECM and can also be initiated based on a model that approximates how much soot/particulate matter is exiting the engine. For example, these models may be based upon speed/load particulate matter tables. A signal to initiate a desulfation cycle may be generated based upon outputs from exhaust NOx sensors, temperature sensors, and air/fuel ratio sensors that are received by the engine control module that in turn initiates desulfation of an NOx adsorber catalyst. The engine control module may also adjust the air/fuel ratio when desulfating a NOx adsorber catalyst. Fueling and timing may also adjust the air/fuel ratio engine operating parameters may be adjusted by the engine control module.

[0019] These and other aspects of the invention will be better understood in view of the attached drawings and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. **1** is a schematic representation of a compression ignition engine having an exhaust system component regeneration system according to the present invention.

[0021] FIG. **2** is a flow charting showing the method regenerating filters according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0022] Referring now to the drawings, wherein like numerals refer to like structures, and particularly to FIG. **1**, a compression ignition engine **10** for an on-highway vehicle **12** is shown schematically. The engine **10** includes an engine control module **14** that controls operation of the engine **10** and also controls exhaust component regeneration and desulfation according to the present invention as described below.

[0023] Exhaust manifold sensors **16**, exhaust sensors **17** located before the aftertreatment **19** and tail pipe sensors **18** provide exhaust temperature and other gas information to the engine control module (ECM) **14** that is used in controlling exhaust component regeneration. Those skilled in the art will recognize that while sensors **16** are depicted as manifold sensors, the sensors could be located in the engine exhaust piping upstream of the after treatment. The exhaust manifold sensors **16** may provide information regarding NOx levels, air/fuel ratios (λ), temperature, and pressure. More specifically, the exhaust manifold sensors **16**, exhaust sensors **17** and pipe sensors **18** may provide information regarding NOx, (λ), and temperature that enable the ECM to detect an impending need for regeneration, or whether the system has acceptable temperatures to effect particulate filter regeneration. The ECM may also monitor other engine operating parameters to determine the need for regeneration, such as engine load and engine rpm to detect an impending need for regeneration. A warning light **26** is activated upon detecting a need for regeneration of a particulate filter **20**, catalyzed soot filter **22**, or NOx adsorber catalyst **24**. Illumination of the warning light prompts the operator to actuate a switch **28** to activate the regeneration/desulfation cycle.

[0024] When the vehicle stops for fuel or for any other reason, the engine **10** normally continues to idle. At this time, with the vehicle stopped, the ECM controls fueling, timing, governing and other engine operating parameters as required to bring the engine to a specified operating speed. If a particulate filter, catalyzed soot filter, or NOx adsorber catalyst is to be regenerated, the air/fuel ratio is also controlled accordingly.

[0025] Sensors **16** and **18** provide information regarding the exhaust gas temperature to the ECM. If the exhaust gas temperature is insufficient to effect regeneration of the particulate filter or the catalyzed soot filter or the NOx adsorber catalyst, sensor **30** in air tubing inlet **32** to the turbocharger **34** provides information to the ECM regarding the temperature of the incoming ambient air. Fuel delivery data tables based upon ambient air temperature are provided within the ECM. The fuel air ratio delivery to the engine is adjusted based upon the ambient air temperature so that engine speed is increased. The increased engine speed results in an increased exhaust gas stream temperature. As the temperature in the exhaust gas stream increases to the temperature necessary to effect particulate filter, catalytic soot filter or NOX adsorber filter regeneration, the ECM senses the condition of the filters and, when they have regenerated, the ECM adjusts the fuel/air ratio delivery each toward normal idle operation so that the operator will not suffer an unduly large fuel economy penalty for filter cleaning operation. Likewise, if temperature is high, it is contemplated that the ECM could reduce engine speed so that fuel economy is improved during the regeneration process. At the end of the regeneration process, the ECM causes the engine speed to resume its normal base idle.

[0026] If the operator fails during a subsequent fuel stop to initiate a regeneration/desulfation cycle after the warning light is illuminated, the ECM may disable the vehicle. The ECM can disable the vehicle by precluding gear engagement in the transmission or by disabling the engine throttle. The ECM may also take other measures to prevent operation of the vehicle until the regeneration/desulfation cycle is initiated by the operator. For example, if the operator fails to initiate a regeneration/desulfation cycle, the ECM may limit fueling to the engine and thereby reduces operation performance of the vehicle. Preferably, if the ECM detects that a regeneration/desulfation cycle is required, a warning light is activated alerting the operator of the need to initiate a regeneration/desulfation cycle. If the operator continues to ignore the warning light, the ECM may derate the engine to protect the filter and reduce the operability of the vehicle. If the engine operator continues to ignore the warning light, the ECM may begin initiating the shut-down of the engine. The operator will have the option of overriding the shutdown. Alternatively, the system may activate an alarm or flash the warning light to provide further advice to the operator as to the necessity of performing the regeneration/desulfation cycle.

[0027] FIG. **2** is a schematic of the steps the ECM initiates to effect the active particulate catalytic soot filter and NOx adsorber regeneration of the present invention. Method **36** is initiated at start **38**. Step **40** is determining whether the engine is idling. If yes, step **42** is determining whether the engine operator requests filter regeneration. Step **44** is determining whether it is acceptable to regenerate the filters. If no, step **46** is to continue idle operation. If yes, step **48** is determining ambient air temperature entering at the compressor. Step **50** is elevating engine rpm to a desired rpm based upon ambient temperature and begin regeneration/desulfation of the filters and NOx adsorber/catalysts. Step **52** is determining whether the exhaust temperature is sufficient to regenerate the particulate filter. If yes, at step **54** the ECM continues engine speed at the desired rpm. If no, step **56** is varying the engine speed using ambient air temperature until the exhaust gas stream temperature is sufficient to regenerate the filters. Once the filters are regenerated, engine speed is decreased and the normal idle fuel delivery is resumed. It is also an integral part of this invention that the range of engine seed operation to effect regeneration is kept within a range that will be as low as possible to reduce engine noise to a minimum and save fuel during the regeneration cycle. A warning light may optimally be provided to alert the operator when the filters require cleaning.

[0028] While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention.

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A method of regenerating particulate filters, catalyzed soot filters, Selective Catalytic Reduction systems and NOx adsorber catalysts for a vehicle equipped with a compression ignition engine having an engine central module (ECM) and an integrated starter/alternator/flywheel/retarder assembly, comprising:

sensing the condition of the particulate filters, catalyzed soot filters, and NOx adsorber catalysts and generating an initiate cleaning cycle signal upon sensing that the filters and catalysts require cleaning;

monitoring operation of the engine and the vehicle to determine whether the engine is idling and whether the vehicle is stopped and generating an engine idling/vehicle stopped signal;

receiving the initiate cleaning cycle signal and the engine idling/vehicle stopped signal;

sensing the temperature of an exhaust gas stream and generating a low temperature signal upon sensing that the exhaust gas temperature is insufficient for regeneration of the filters;

sensing the ambient air temperature of incoming air into a turbo compressor on the engine.

initiating engine control parameter adjustments based upon ambient air temperature and/or exhaust gas temperature to increase or decrease engine speed and exhaust gas temperature to regenerate the filters;

resuming normal engine idle operating parameters when filters are regenerated.

2. The method of claim **1**, wherein sensing the condition of the filter is accompanied by sensing back pressure in the exhaust system.

3. The method of claim **2**, wherein the cleaning cycle is initiated when the exhaust back pressure exceeds a pre-determined level, and ceases when the exhaust system back pressure is below a second pre-determined level.

4. The method of claim **1**, wherein the cleaning cycle is initiated when a the ECM, based upon a modeled approximation of soot initiates the particulate filter regeneration cycle, and the particulate filter regeneration cycle ceases based upon the modeled approximation of soot.

5. The method of claim **1**, further comprising a NOx adsorber catalyst by adjusting the air/fuel ratio.

6. The method of claim **1**, wherein the engine operating parameters adjusted by the engine central module are fueling and timing parameters.

7. The method of claim **1**, further comprising actuating a warning light in response to the engine control module receiving the signal to initiate a regeneration cycle.

8. The method of claim **7**, wherein upon activating the warning light, the engine central module initiates steps such as engine derate or possible engine shut down unless an operator initiates the regeneration cycle.

9. The method of claim **8**, further comprising actuating a manual switch by the operator upon activation of the warning light.

10. A system for regenerating particulate filters, catalyzed soot filters, Selective Catalytic Reduction systems, and NOx absorber catalysts for a compression ignition engine of a vehicle, comprising:

a starter;

an alternator;

a flywheel;

a retarder, wherein the starter, alternator, flywheel and retarder are combined as an integrated assembly;

a load bank heater disposed in an exhaust pipe; and

an engine control module adapted to receive a signal to initiate a regeneration cycle, wherein the engine control module senses exhaust gas temperature and turbo compressor inlet ambient air temperature adjusts engine operating parameters after receiving the initiate regeneration cycle signal when the vehicle is at rest and the engine is idling, wherein the signal to initiate the regeneration cycle includes a desulfation cycle of a NOx absorber catalyst that is initiated in response to signals received from at least one exhaust NOx sensor, at least one exhaust gas temperature sensor, and at least one air/fuel ratio sensor by the engine control module.

11. The system of claim **10** wherein the exhaust gas temperature sensor generates a low temperature signal indicating that the exhaust temperature is below a predetermined level that is sufficient for regeneration, wherein the load bank heater is activated that raises the temperature of the exhaust in conjunction with increasing the load on the engine applied by the integrated assembly, wherein the engine control module brings the engine to a specified operating speed.

12. The system of claim **10** wherein the signal to initiate a regeneration cycle for a filter is generated by a sensor in the exhaust that monitors exhaust back pressure.

13. The system of claim **10**, wherein the cleaning cycle is initiated when a the ECM, based upon a modeled approximation of soot initiates the particulate filter regeneration cycle, and the particulate filter regeneration cycle ceases based upon the modeled approximation of soot.

14. The system of claim **10** wherein during the desulfation cycle of a NOx absorber catalyst the engine operating parameter adjusted is the air/fuel ratio.

15. The system of claim **10** wherein the engine operating parameters adjusted by the engine control module are fueling and timing parameters.

16. The system of claim **10** wherein a warning light is activated in response to the engine control module receiving the signal to initiate a user requested regeneration cycle.

17. The system of claim **16** wherein upon activating the warning light, the engine control module disables the engine unless an operator initiates the regeneration cycle.

18. The system of claim **16** wherein the operator activates the regeneration cycle by actuating a manual switch upon activation of the warning light.

19. A method of regenerating particulate filters, catalyzed soot filters, Selective Catalytic Reduction systems and NOx adsorber catalysts for a vehicle equipped with a compression ignition engine having an engine central module (ECM) and an integrated starter/alternator/flywheel/retarder assembly, comprising:

a) determining whether the engine is idling;

b) determining whether an engine user is requesting regeneration;

c) determining whether it is acceptable to initiate regeneration;

d) determining ambient temperature of air to inlet of turbo air compressor;

e) elevating engine rpm to a desired engine rpm based upon ambient temperature and initiate regeneration and desulfation;

f) determining whether the exhaust gas temperature is sufficient to regenerate the particulate filter; and

g) varying the engine speed using ambient air temperature until the exhaust gas temperature is sufficient to regenerate the particulate filter

20. The method off claim **19**, wherein if it is determined not to be acceptable to initiate regeneration, engine idle is continued, and where if the exhaust temperature is determined to be sufficient to regenerate particulate filter, engine speed is continued at a desired rpm.

* * * * *