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METHOD AND SYSTEM FOR REGENERATION OF A CATALYST

BACKGROUND

The present invention relates to a system and a method for improving performance of an exhaust gas after-treatment system, and more particularly to regenerating a catalyst to improve its NO_x conversion efficiency.

Current emission control regulations necessitate the use of catalysts in the exhaust systems of automotive vehicles in order to convert carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NO_x) produced during engine operation into harmless exhaust gasses. Vehicles equipped with diesel or lean gasoline engines offer the benefit of increased fuel economy. Such vehicles are typically equipped with exhaust after-treatment systems that employ one or more catalysts to assist in chemically converting NO_x, hydrocarbons, carbon monoxide, and other pollutants into less harmful compounds prior to discharge of the exhaust to the environment.

However, in such traditional catalyst systems, soot, hydrocarbons, and other undesirable species may adsorb on the surface of the catalyst, thus contaminating the catalyst and reducing its conversion efficiency. Periodically heating the catalyst systems to a temperature above the boiling point of hydrocarbons, or the regeneration temperature of soot, for a predetermined amount of time, can regenerate the catalyst by removing deposits of undesirable materials.

Known methods of regeneration may involve complex operations such as switching many streams of exhaust and activating many valves. Such systems employ complex subsystems such as cooling fans, multiple catalyst beds, and the like. Additionally, these systems also require valuable space and additional fuel consumption. Therefore, there is need for an improved system and method for regeneration of catalysts.

BRIEF DESCRIPTION

Briefly, in accordance with one embodiment of the invention, there is provided a system for regeneration of a catalyst. The system includes an engine that creates an

exhaust stream, a reactor that includes a catalyst and is in fluid communication with the engine to receive the exhaust stream and a sensor that measures a system parameter related to the engine or the reactor and produces a signal corresponding to the system parameter. The system also includes a controller that receives the signal and directs the exhaust stream to the catalyst if the system parameter is indicative of a regeneration value.

In accordance with another embodiment of the invention, there is provided a method for regeneration of a catalyst. The method includes sensing a temperature of the catalyst and a temperature of an exhaust stream from an engine and passing the exhaust stream over the catalyst in response to the sensing of the temperature of the catalyst and the temperature of the exhaust stream if the temperature of the catalyst and the temperature of the exhaust stream indicate a regeneration condition. The method also includes controlling the temperature of the catalyst and the temperature of the exhaust stream to regenerate the catalyst and monitoring regeneration of the catalyst.

DRAWINGS

FIG. 1 is a schematic diagram of a locomotive engine that uses a system in accordance with the present technique for regeneration of catalyst;

FIG. 2 is a schematic diagram of an exemplary system for regeneration of catalyst in a diesel engine exhaust treatment system in accordance with one embodiment of the present technique;

FIG. 3 is a schematic diagram of a reactor bed containing catalyst in accordance with one embodiment of the present technique;

FIG. 4 is a schematic diagram of an exemplary system for regeneration of catalyst in a diesel engine exhaust treatment system in accordance with one embodiment of the present technique; and

FIG. 5 is a flow chart that shows a process for regeneration of catalyst in accordance with one embodiment of the present technique.

DETAILED DESCRIPTION

FIG. 1 is a schematic diagram of a railroad locomotive that uses an exemplary system for regeneration of catalyst in a diesel engine exhaust treatment system in accordance with one embodiment of the present technique. A train 1 runs on a rail 2. A locomotive 3 includes a diesel engine 4 to drive the train 1. The locomotive 3 is equipped with an exhaust treatment system 6 to treat the exhaust coming out from the engine 4. The exhaust treatment system 6 includes catalyst used for exhaust treatment. The locomotive 3 also includes a system 10 for regeneration of the catalyst in exhaust treatment system 6. Although FIG. 1 shows a locomotive, those of ordinary skill in the art will appreciate the applicability of the present technique to other systems that employ catalyst. For example, the present technique may be employed in other vehicles that have combustion engines, such as passenger vehicles, buses, ships or the like.

According to an exemplary embodiment of the present technique, vehicles equipped with diesel or lean gasoline engines offer the benefit of increased fuel economy. Such vehicles typically produce pollutant gases such as carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NO_x) and the like during engine operation. Emission control regulations encourage the use of catalyst in the exhaust treatment systems of vehicles in order to convert these pollutant gases into harmless exhaust gasses. In one embodiment of the invention, these engines, therefore, may be equipped with exhaust treatment systems that include after-treatment devices such as a Selective Catalytic Reduction (SCR) catalyst, in which NO_x is continuously removed by active reductants. Such reductants may include hydrocarbon compounds. In another embodiment of the invention, a typical exhaust treatment system may also include a conversion catalyst coupled upstream of the SCR catalyst to convert hydrocarbons and carbon monoxide in the exhaust gas mixture.

Typically, soot and unreduced hydrocarbons adsorb on the surface of the catalyst during operation of the engine. The adsorbed species insulate the active surface of the catalyst from the exhaust stream, thereby reducing the efficiency of the catalyst. Therefore, there is usually a need to periodically heat the catalyst systems to a

temperature above the boiling point of hydrocarbons or above the temperature at which soot can be “burned off” of the catalyst, for a predetermined amount of time, to clean the surface of the catalyst. This process is known as “regenerating” the catalyst.

One exemplary technique of regeneration includes the use of a catalyst for the oxidation of the nitrogen monoxide (NO) contained in the exhaust gases into nitrogen dioxide (NO₂). Under certain conditions, such as where a low-sulfur diesel fuel is being used as fuel in the engine, NO₂ has the property of catalyzing combustion of carbon-based soot particles beginning at about 250° C. Desirably efficient operation is often obtained when the exhaust gases or the reactor in which the combustion of soot is to occur are at a temperature in excess of 300° C for at least 30% of the operating time of the vehicle. Because maintaining the catalyst in a desirable range consumes energy, the regeneration system should be as fuel efficient as possible. Moreover, regeneration of catalyst should occur at a time when the catalyst is not performing its primary function, such as, for example, producing a reductant to be used for pollution removal downstream, or for converting NO_x to nitrogen.

Effective regeneration of catalysts can be done in accordance with the requirements described above by performing regeneration of the catalyst while an engine is set at the operating level referred to as “notch 2” by those of ordinary skill in the art. In one aspect of the present technique, the exhaust from the engine operating at notch 2 is used for the purpose of regeneration. In yet another embodiment of the invention, the injection timing of fuel in the engine is altered for the purpose of regeneration.

The catalyst regeneration system 10 will be described in more detail below. In this context, a ‘light-off temperature’ is typically defined as the temperature at which fifty percent (50%) of the emissions from the engine are being converted as they pass through the catalyst. The time period between ‘cold start’ and reaching the ‘light-off temperature’ is generally referred to as the ‘light-off time’.

FIG. 2 is a schematic diagram of an exemplary system 10 for regeneration of catalyst in a diesel engine exhaust treatment system 6 in accordance with aspects of the present technique. Referring to FIG. 2, a diesel engine 12, supplied with fuel from a

main reservoir 14 via a supply system 42, produces exhaust gases during operation. These gases are recovered using a manifold (not shown) at the outlet of the engine, and are discharged through a discharge line 34. The system 10 includes a temperature sensor 22 disposed in the discharge line 34 to measure the temperature inside the discharge line 34. The discharge line 34 supplies the exhaust stream to a reactor 16 containing a catalyst 18. A temperature sensor 24 is also placed in the reactor 16 to sense the temperature of the catalyst 18. The system 10 also includes an engine notch level sensor 26 coupled to and positioned near engine 12 for sensing the notch level of the engine. As explained earlier, combustion conditions occurring in the engine 12 at the notch 2 level have been found to be suitable for use in the regeneration system 10.

The discharge line 34 in the regeneration system 10 branches out in two lines on reaching the reactor 16. One reactor heating line 31 carries a part of the exhaust stream, passes through the reactor 16 and directs the exhaust stream over the catalyst 18. The other branch of the discharge line 34, the bypass exhaust line 33, bypasses the reactor 16 and directs the remaining part of the exhaust stream out of the engine. A flow control valve 28 is disposed in the discharge line 34 at the junction of the reactor heating line 31 and the bypass exhaust line 33. The flow control valve 28 selectively diverts part of the exhaust stream into the reactor heating line 31. A controller 19 is connected to the flow control valve 28 by command line 52. The controller 19 monitors and controls the opening and closing of the valve 28. The flow control valve 28 is typically a solenoid valve and opening and closing of the solenoid valve leads to the more or less volume flow of exhaust stream into the reactor heating line 31 and thereby in the reactor 16.

The reactor 16 as shown in FIG. 2 is typically made of a stainless steel casing (not shown), a thermal insulator (not shown) and a support (not shown) impregnated with catalyst. The reactor 16 is typically manufactured by coating the support with a metal or ceramic material with a high surface area, such as metal oxide particles. The material of the catalyst 18 is deposited on the high surface area material of the reactor 16.

In some embodiments, the catalyst 18 described in this embodiment comprises one or more metals, such as platinum or other noble metal.. In another embodiment, the catalyst 18 is a transition metal-exchanged zeolite. For instance, the transition metal may be copper, and the zeolite may be a copper exchanged ZSM5 zeolite. Typically, the catalyst is capable of selectively reducing nitrogen oxides with hydrocarbons in the presence of oxygen so that at least about 30% of the nitrogen oxides are converted. More preferably, this amount is at least about 50%, under the operating temperatures of the engine 12. Referring again to FIG. 2, in particular embodiments, the nitrogen monoxide (NO) contained in the exhaust gases is converted by the catalyst 18 into nitrogen dioxide (NO₂).

In one embodiment, the reactor 16 and thereby the catalyst 18 are heated up by contact with high temperature exhaust gases from the engine 12. This heating, in conjunction with the exothermic nature of the oxidation reaction occurring at the catalyst 18, will bring the catalyst to light-off temperature. However, until the light-off temperature is reached, the exhaust gas passes through the catalyst relatively unchanged. In addition, the composition of the engine exhaust changes as the engine heats from the cold start temperature, and the reactor 16 is typically designed to work best with the composition of the exhaust stream produced at the normal elevated engine operating temperature.

Referring again to FIG. 2, a controller 19 controls and coordinates the activities of the sensors 22, 24 and 26 and the flow control valve 28 to coordinate the overall functioning of the system 10. Structurally, the controller 19 may comprise a micro-controller or a solid-state switch configured to communicate with the sensors 22, 24, 26 and the flow control valve 28. This communication may take place using the sensing signal line 54 from the exhaust stream temperature sensor, sensing line 56 from the catalyst temperature sensor, sensing line 58 from the engine notch level sensor and the command line 52 from the flow control valve respectively. In one embodiment, the controller 19 comprises an analog-to-digital converter accessible through one or more analog input ports. In another embodiment, the controller 19 may include read-out displays, read-only memory (not shown), random access memory (not shown), and a conventional data bus (not shown).

As will be recognized by those of ordinary skill in the art, the controller 19 may be embodied in several other ways. In one embodiment, the controller 19 may include a logical processor (not shown), a threshold detection circuitry (not shown) and an alerting system (not shown). Typically, the logical processor is a processing unit that performs computing tasks. It may be a software construct made up using software application programs or operating system resources. In other instances, it may also be simulated by one or more physical processor(s) performing scheduling of processing tasks for more than one single thread of execution thereby simulating more than one physical processing unit. The controller 19 aids the threshold detection circuitry in estimating an emission parameter such as NO_x efficiency, HC efficiency or CO efficiency based on the strength of the exhaust from the engine 12. This estimate information may be reported to a remote control unit (not shown) or to an alerting system (not shown) whether the catalyst is regenerated completely.

In operation, controller 19 monitors and controls the temperature of the reactor 16. In one embodiment, the controller 19 determines and interprets the temperature of the reactor bed 16 based on the temperature sensing signals from the temperature sensors 24 disposed in the reactor bed 16. The determination and interpretation by the controller 19 is done in accordance with a predetermined criterion. For instance, in one embodiment, the predetermined criterion may include a binary comparison of the temperature of the reactor bed 16 with a predetermined reference value of temperature. In another embodiment, the predetermined criterion may comprise comparison of the temperature of the reactor bed 16 with a predetermined maximum value of temperature. In yet another embodiment, the predetermined criterion may comprise comparison of the temperature of the reactor bed 16 with a predetermined minimum value of temperature.

Whatever the criterion for comparison, if the sensed temperature of the reactor bed 16 falls outside of the predetermined reference range, the controller 19 may determine that the status of the catalyst 18 is not acceptable and the reactor 16 needs extra heating. In that event, the controller 19 sends a command signal to the flow control valve 28 and regulates the opening of the flow control valve 28 so that an additional amount of exhaust stream is diverted into the reactor heating line 31. In another

embodiment, if the controller 19 senses that the reactor 16 needs extra heating, it sends an alarm signal to the alerting system and the alerting system in turn generates an appropriate alarm to a process observer at a remote location (not shown). In yet another embodiment, the operating status of the catalyst 18 and any need of extra heating is determined by logically processing one or more emission parameters such as NO_x or HC or CO conversion efficiency of the regeneration system 10.

FIG. 3 is a schematic diagram of the reactor 16 as implemented in a diesel engine in accordance with aspects of the present technique. Those components in system 10 of FIG. 2 that are identical to components of FIG. 3 are identified using the same reference numerals used in FIG. 2. In addition to the components of system 10, the reactor 16 in FIG. 2 contains a second catalyst 17. The second catalyst 17 typically, but not necessarily, comprises a noble metal such as, for example palladium. The second catalyst may comprise one or more of a number of catalyst types, including, for instance, an SCR catalyst, a catalyst for reduction of hydrocarbon species, or a hybrid catalyst made of a number of various types of catalysts. A second catalyst temperature sensor 25 is also placed in the reactor 16. The function of the sensor 25 is to measure the temperature in the vicinity of the second catalyst 17. The controller 19 is connected to the sensor 25 by the sensing signal line 57.

In typical dual bed catalytic reactors commonly found in prior art, one bed regenerates while the other one performs its primary function. Such systems employ complex subsystems such as cooling fans and the like. Additionally, these systems also require valuable space and additional fuel consumption. Moreover, these traditional dual bed systems are complex and expensive to operate. In contrast, in this embodiment, both the catalyst 18 and the second catalyst 17 can be regenerated at the same time using the same stream of exhaust gases from the diesel engine 12. Moreover, the system as illustrated in this embodiment of the invention, is simple, easy to deploy and economic in fuel utilization. In another embodiment of the invention the reactor heating line 31 may further branch out inside the reactor 16 in two lines (not shown) to supply different volume flow of the exhaust stream to the two different catalysts. In the operation according to one embodiment of the invention, the catalyst 18 exothermally combusts hydrocarbons in the incoming exhaust gas from the engine

thus supplying heat to rapidly warm up the second catalyst 17. The temperature of the second catalyst 17 is continuously monitored by the controller 19 using the temperature sensor 25. The controller 19 also controls the operational parameters of the engine 12 so that the temperature of the second catalyst 17 remains above the regeneration point.

Various methods may be used, where needed, for raising the temperature of the second catalyst 17, such as by retarding injection timing, by increasing exhaust gas recirculation (EGR) and intake throttling, or by any other means known to those skilled in the art to increase the temperature of the exhaust gas. Alternatively, extra hydrocarbons may be delivered to the catalyst 18 to warm-up second catalyst 17 by in-cylinder injection during either or both of a power or exhaust stroke of the engine 12.

In another alternative embodiment (not shown), a reductant delivery system (not shown) may be used to increase the hydrocarbon concentration in the exhaust gas mixture in reactor heating line 31 that enters the reactor 16 to interact with the catalyst 18.

Alternatively, in yet another embodiment, the amount of NO_x in the exhaust gas mixture entering the second catalyst 17 can be estimated based on engine speed, load, exhaust gas temperature or any other parameter known to those skilled in the art to affect engine NO_x production. A suitable method may be adopted in this embodiment to supply extra hydrocarbon as described above in case of any such requirement. Referring back to FIG. 3, in yet another embodiment, the catalyst 18 and the second catalyst 17 described above may be combined physically and functionally into a hybrid catalyst. The material of the hybrid catalyst, in some embodiments, may be an intimate mixture of the catalyst 18 and the second catalyst 17 or a layered combination of them.

In another embodiment, the lower part of the reactor 16 (FIG. 3) may contain an additional retention chamber to increase the residence time in the reactor for the exhaust gases. This extension of the residence time of the exhaust gases allows them

to heat the catalyst 18 and the second catalyst 17. A result is that the second catalyst 17 may be maintained at a temperature much higher than the usual temperature.

As will be appreciated by those of ordinary skill in the art, embodiments of the present technique are not limited to the above-described configuration of the system. FIG. 4 is a schematic diagram of another exemplary system for regeneration of catalyst in a diesel engine exhaust treatment system. Those components in system 20 that are identical to components of system 10 of FIG. 2 or FIG. 3 are identified in FIG. 4 using the same reference numerals used earlier. In addition to the components of system 10, the system includes a fuel injection control valve 32 to control the amount of fuel injected into the combustion chamber of the engine. The control valve 32 is connected to the controller 19 by command line 48. The controller 19 monitors and controls the opening of the control valve 32. Moreover, the reactor 16 in system 20 of FIG. 4 further includes a heating element 29. The structure and function of this extra heating element will be described in more details below.

In this embodiment of the invention, fast catalyst warm-up and thereby improved NO_x conversion efficiency is achieved by increasing the hydrocarbon concentration in the exhaust gas mixture entering the catalyst 18. The increase in hydrocarbon concentration may be accomplished by adjusting engine-operating conditions, such as injection timing. The extra hydrocarbons thus produced in the exhaust stream in discharge line 34 burn in the catalyst 18. The temperature in the vicinity of the catalyst 18 is measured using the sensor 24 respectively. The controller 19 compares these values with reference values corresponding to an optimum temperature at which regeneration of the catalyst 18 takes place. In the embodiment illustrated in FIG. 4, if the temperature is not sufficient to initiate regeneration of the catalyst 18, the controller 19 controls the amount of fuel carried to the engine 12 for combustion through the fuel injection line 44. This functionality of the controller 19 is further explained below. The controller 19, moreover, controls the amount of exhaust stream carried through the discharge line 34 by controlling the flow control valve 28 as explained earlier in relation to description of system 10 in FIG. 2.

Referring to FIG. 4 again, in one embodiment of the invention, an extra heating element 29 is provided to the reactor 16 to shorten or avoid the light-off time. The extra heating element 29 may comprise devices such as burners, electrical resistors or the like. In one embodiment, the heating element is an electrically heated cylindrically shaped heating element. Alternatively, in another embodiment, the heating element may be rectangular shaped to increase its surface contact area with the reactor 16 and the catalyst 18. Controller 19 can selectively enable and disable switching of the heating element 29 by command line 59 depending on various operating conditions, such as engine speed, load, exhaust gas temperature and the like.

The controller 19 is connected to the secondary fuel supply line to engine 44 and controls the opening of this line by controlling the opening of the flow control valve 32. The flow control valve 32 is electrically controlled by the controller 19 by control command line 48. The flow control valve 32 is typically a solenoid valve and opening and closing of the solenoid valve leads to the more or less volume flow of diesel fuel to the combustion chamber (not shown) of the engine 12.

The secondary reservoir 36 supplies the injection chamber 38 with diesel fuel through fuel supply line 46 to injection chamber 38. The secondary reservoir 36 is itself supplied from the main reservoir 14 through a pipe system 35. The secondary fuel supply line 44 connects the engine 12 to the injection chamber 38. The lines 44 are opened using the solenoid valves 28 and 32. The controller 19 as shown in FIG. 4 is enhanced over its configuration discussed in relation to FIG. 2 by incorporating the additional functionality of controlling the amount of diesel fuel entering the diesel engine 12. In one embodiment, the controller 19 controls the amount of fuel carried to the engine 12 for combustion through the fuel injection line 44 by controlling the opening and closing the fuel injection valve 32. The controller 19 communicates with the fuel injection valve 32 by the command line 48 to achieve the control of the above described fuel injection valve 32. In another embodiment, the controller 19 is equipped with a timer (not shown) to monitor and control the amount of fuel injected into the combustion chamber by indirectly controlling the duration of injection. As explained above, in order for the regeneration to take place with desirable efficiency, the time for which the temperature of the exhaust gases is in excess of 300° C should be more

than 30% of the working time of the vehicle. The controller 19 described in this example facilitates an exhaust gas temperature constantly in excess of 300° C.

In operation, if the measured temperature of the reactor bed 16 is less than or equal to a reference value, the controller 19 coordinates the opening of the flow control valves 28 and 32. Opening of flow control valve 32 leads to more fuel injected into the engine and extra combustion takes place in the combustion chamber (not shown) of engine 12. At the same time, opening of flow control valve 28 leads to more volume flow of exhaust stream in the reactor heating line 34. Thus, by sensing the two temperature sensors 22 and 24 and by operating the flow control valves 28 and 32 in tandem, the controller 19 facilitates complete regeneration of the catalyst 18 in the reactor bed 16.

FIG. 5 is an exemplary method flow chart for regeneration of catalyst in a diesel engine exhaust treatment system in accordance with aspects of the present technique. An exemplary routine for catalyst regeneration as explained in FIG. 5 in accordance with aspects of the present technique is presented. As will be appreciated by one of ordinary skill in the art, the routine may represent one or more of any number of processing strategies such as event-driven, interrupt-driven, multi-tasking, multi-threading, and the like. As such, various steps or functions illustrated may be performed in the sequence illustrated, in parallel, or in some cases omitted. Likewise, the order of processing is not necessarily required to achieve the objects, features and advantages of the invention, but is provided for ease of illustration and description. Although not explicitly illustrated, one of ordinary skill in the art will recognize that one or more of the illustrated steps or functions may be repeatedly performed depending on the particular strategy being used.

The method of regeneration of catalyst starts as in functional block 72. The operating engine notch level is sensed as in functional block 74 and once the notch level 2 is reached, exhaust stream from the engine is carried out to the regeneration system as in functional block 76. The exhaust stream is passed over the reactor and the catalyst as in functional block 78. The temperature sensors embedded in the reactor and the catalyst sense the temperature of reactor and catalyst as in functional block 82. The

reactor temperature is monitored by the controller 19 as in functional block 84. If necessary, the reactor is heated as in functional block 85. At the same time, the volume flow rate of exhaust stream is monitored and controlled as in functional block 86. In another embodiment, the fuel injection timing is monitored and controlled as in functional block 87. The regeneration of the catalyst is monitored and controlled as in functional block 88 and it is verified whether the regeneration process is acceptable or not as in functional block 92. If it is acceptable, regeneration of the catalyst is continued as in functional block 94. On the other hand, if the regeneration process is not acceptable, it is verified whether regeneration is to be stopped altogether as in functional block 96. If not, then the control goes back to the functional blocks 86 and 87, whereby the volume flow rate of exhaust stream and the fuel injection timing are monitored and controlled. On the other hand, if regeneration is stopped, the method 30 of catalyst regeneration in accordance with one embodiment of this invention comes to an end as in functional block 98.

Therefore, according to aspects of the present technique, it is possible to improve NO_x conversion efficiency of a catalyst by removing stored contaminants, such as hydrocarbons and soot, from its storage sites. This can be accomplished by a regeneration process wherein the temperature of the catalyst is maintained above a predetermined temperature for a sufficient amount of time to boil off adsorbed hydrocarbons and remove soot deposits.

The principles of the invention are not limited to only railroad locomotive engines. One of ordinary skill will recognize that other embodiments of the invention are suited for other types of vehicles that use internal combustion engines. For example, internal combustion engines that are used in vehicles that run on roads such as municipal transport vehicles or city buses or passenger vehicles or in ships may be installed with this type of regeneration systems. In fact, the gases produced by these vehicles are generally at a temperature below that necessary in order to allow regeneration of conventional catalysts, which leads to clogging of these catalysts and therefore their rapid deterioration owing to vigorous combustion reactions. Existing systems, however, generally use organo-metallic additives in order to catalyze the particle combustion, which leads to a significant operating cost. The device according

to the invention, associated with its regeneration method, makes it possible to overcome this problem of cost.

While only certain features of the invention have been illustrated and described herein, many modifications and changes will occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention.

CLAIMS:

1. A system for regeneration of a catalyst, comprising:

an engine that creates an exhaust stream;

a reactor that includes a catalyst and is in fluid communication with the engine to receive the exhaust stream;

a sensor that measures a system parameter related to at least one element selected from the group consisting of the engine, the reactor, and any combination thereof and produces a signal corresponding to the system parameter; and

a controller that receives the signal and directs the exhaust stream to the catalyst if the system parameter is indicative of a regeneration value.
2. The system according to claim 1, comprising a flow control apparatus configured to control an amount of the exhaust stream delivered to the catalyst.
3. The system according to claim 1 wherein the system parameter comprises a notch level of the engine.
4. The system according to claim 3 wherein the regeneration value is a notch level two (2).
5. The system according to claim 1 wherein the system parameter comprises a temperature of the catalyst.
6. The system according to claim 1 wherein the system parameter comprises a temperature of the exhaust stream.
7. The system according to claim 1 further comprising an electric heater configured to boost a temperature of the reactor.
8. The system according to claim 1, wherein the controller is further configured to control a fuel injection timing of the engine.

9. The system according to claim 1, wherein the catalyst comprises a conversion catalyst.
10. The system according to claim 1, wherein the catalyst comprises a hydrocarbon-based selective catalytic reduction catalyst.
11. The system according to claim 1, wherein the catalyst comprises a hybrid catalyst.
12. The system according to claim 1, wherein the engine comprises a diesel engine that is used to power a locomotive.
13. A railroad locomotive comprising:
- an engine that includes at least one cylinder that creates an exhaust stream;
- a fuel injection system coupled to the engine and comprising at least one fuel injector, the fuel injection system configured to inject fuel into the at least one cylinder;
- a reactor that includes a catalyst, is in fluid communication with the engine to receive the exhaust stream;
- a sensor that measures a system parameter related to at least one element selected from the group consisting of the engine, the reactor, and any combination thereof and produces a signal corresponding to the system parameter; and
- a controller that receives the signal and directs the exhaust stream to the catalyst if the system parameter is indicative of a regeneration value.
14. The system according to claim 13 further comprising an electric heater configured to boost a temperature of the reactor.
15. The system according to claim 13, wherein the controller is configured to control a fuel injection timing of the engine.

16. The system according to claim 13, wherein the controller is further connected to the fuel injection system and configured to control a fuel injection timing of the engine by controlling the fuel injector.

17. A method for regeneration of a catalyst, comprising:

sensing a temperature of the catalyst and a temperature of an exhaust stream from an engine;

passing the exhaust stream over the catalyst in response to the sensing of the temperature of the catalyst and the temperature of the exhaust stream if the temperature of the catalyst and the temperature of the exhaust stream indicate a regeneration condition;

controlling the temperature of the catalyst and the temperature of the exhaust stream to regenerate the catalyst; and

monitoring regeneration of the catalyst.

18. The method according to claim 17, comprising controlling a flow of the exhaust stream.

19. The method according to claim 17 comprising sensing a notch level of the engine and sending a signal indicating the notch level to a controller.

20. The method according to claim 17 further comprising heating a reactor that comprises the catalyst.

21. The method according to claim 17, comprising controlling a fuel injection timing of the engine.

22. The method according to claim 17, wherein the catalyst comprises hydrocarbon based selective catalytic reduction catalyst.

23. The method according to claim 17, wherein the catalyst comprises conversion catalyst.

24. The method according to claim 17, wherein the catalyst comprises hybrid catalyst.
25. The method according to claim 17, wherein the engine is used in a locomotive.
26. The method according to claim 17, wherein the diesel engine is used in an exhaust gas recirculation application.

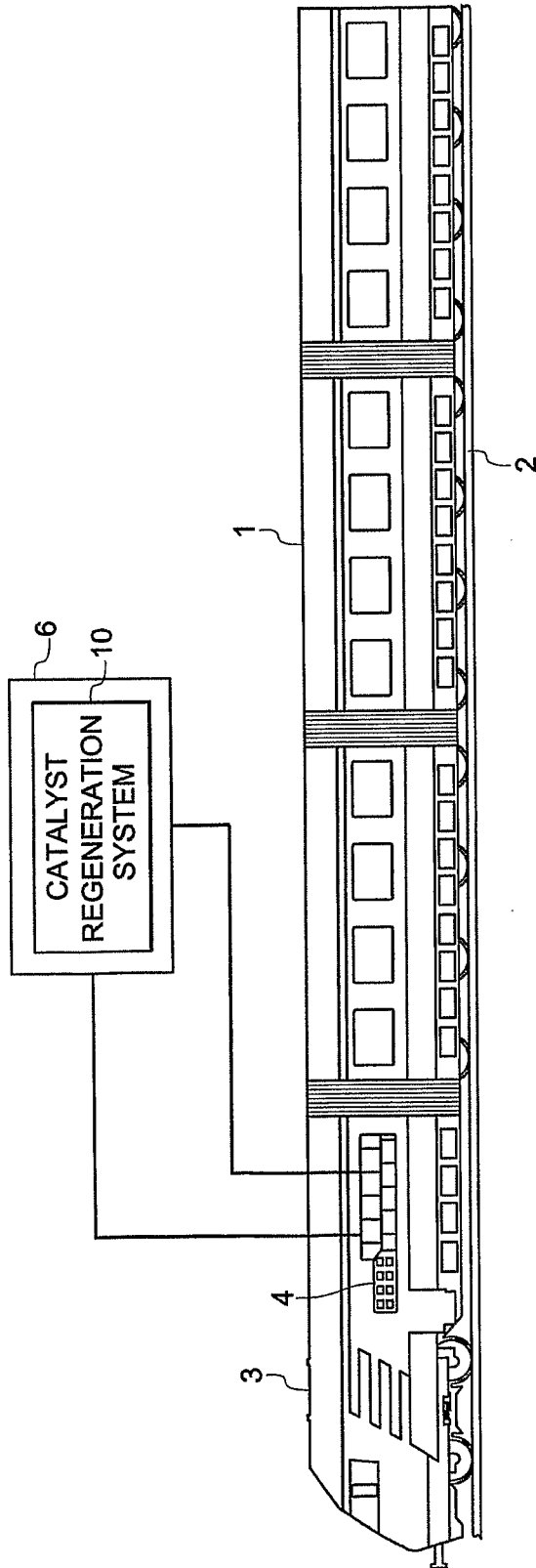


FIG.1

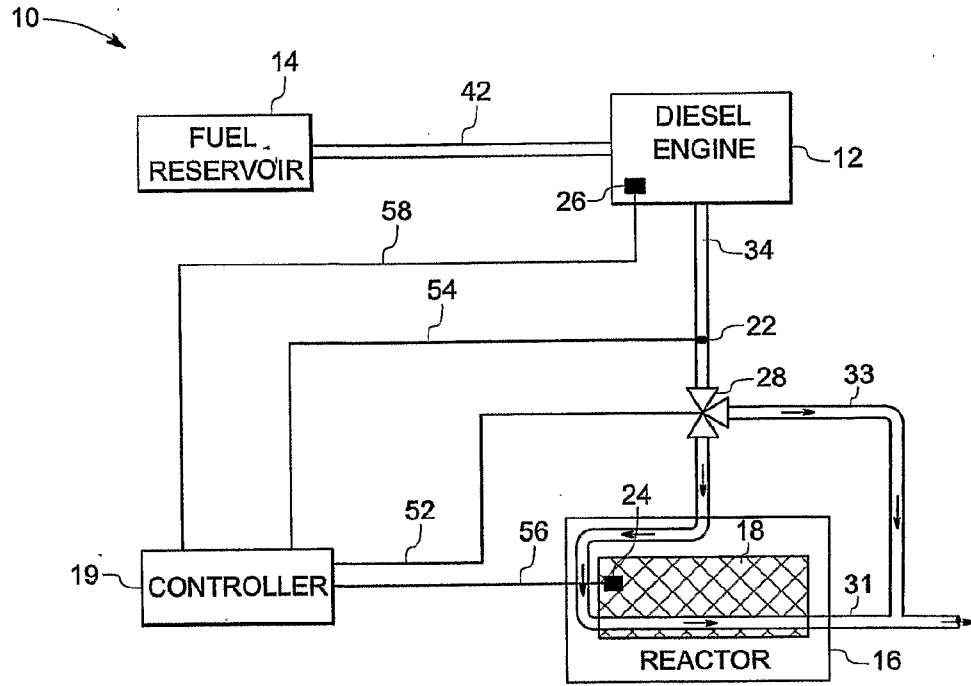


FIG.2

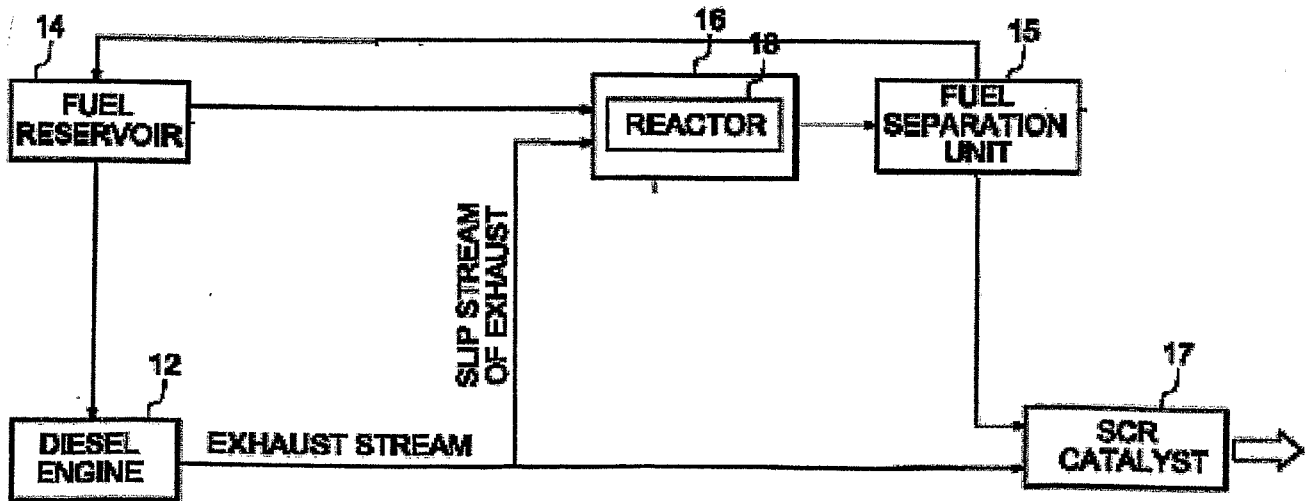


FIG.3

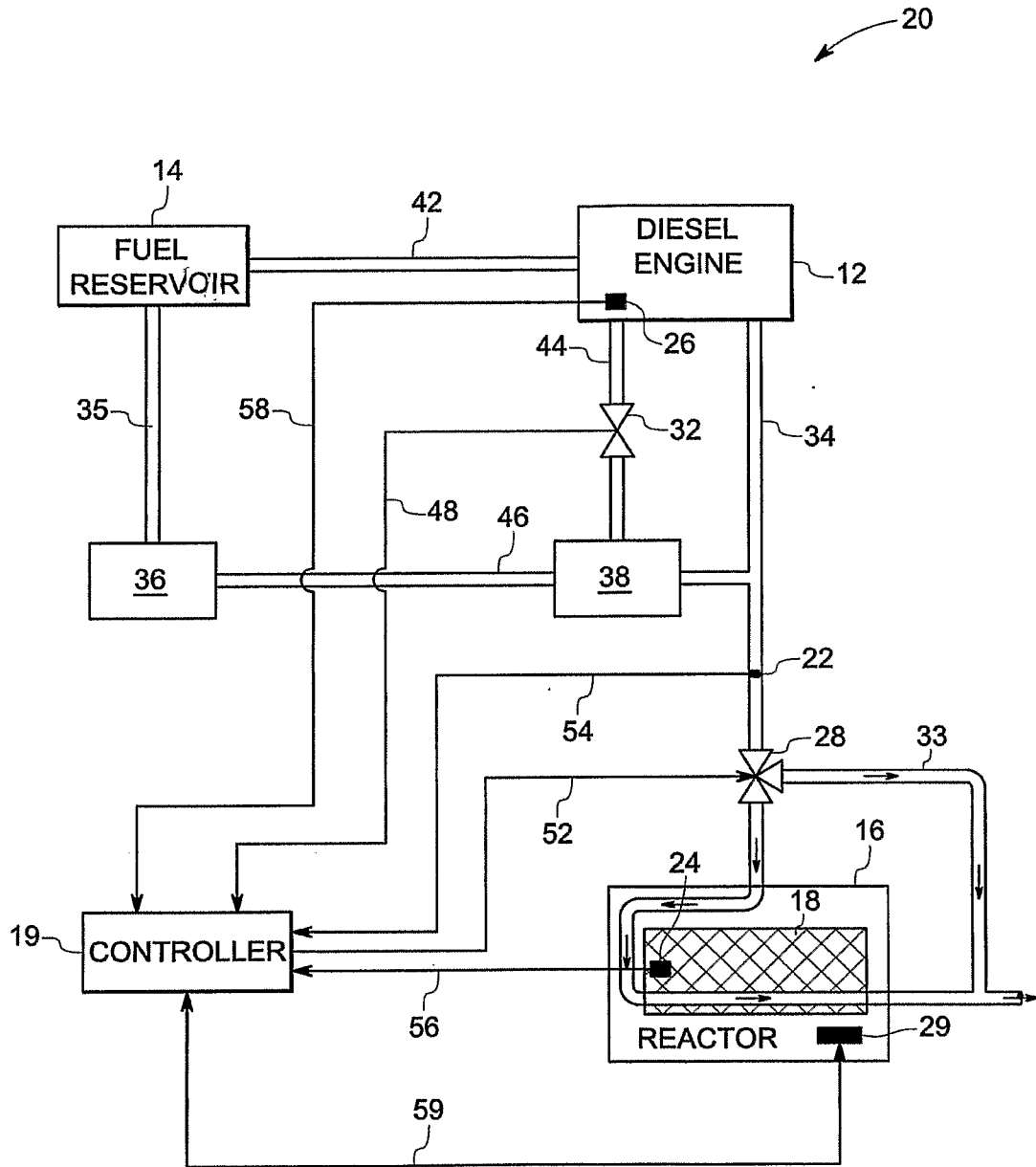


FIG.4

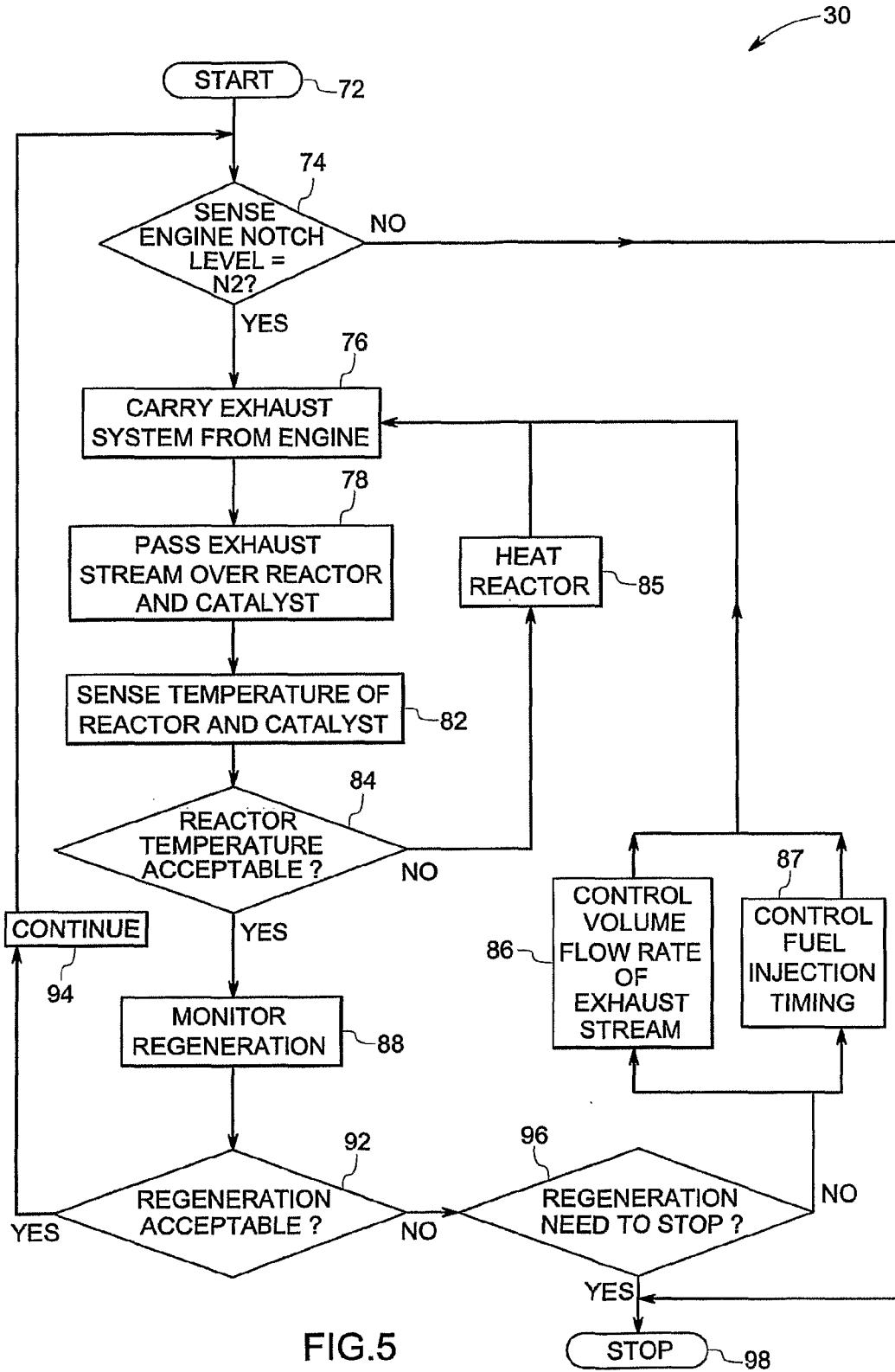


FIG.5