An engine (12) has an exhaust system (16) containing a diesel particulate filter (DPF 20) and timer-based warning structure (30) for detecting and indicating particulate overloading of the DPF as the engine runs.
STATE_EGBP_PF = 7: DPF missing
STATE_EGBP_PF = 6: DPF leaking
STATE_EGBP_PF = 5: DPF clean
STATE_EGBP_PF = 4: DPF partly-loaded with soot
STATE_EGBP_PF = 3: DPF loaded with soot to normal regeneration trigger point
STATE_EGBP_PF = 2: DPF overloaded with soot greater than normal regeneration trigger point
STATE_EGBP_PF = 1: DPF severely overloaded
Figure 3A
Figure 3B
TIMER-BASED WARNING STRUCTURE FOR DETECTING AND INDICATING AN OVERLOADED DIESEL PARTICULATE FILTER

FIELD OF THE INVENTION

[0001] This invention relates to monitoring after-treatment devices in engine exhaust systems in motor vehicles, and in particular to a time-based structure for detecting and indicating an overloaded diesel particulate filter (DPF).

BACKGROUND OF THE INVENTION

[0002] A DPF treats engine exhaust passing through the engine exhaust system by trapping particulate matter to prevent its escape to atmosphere. From time to time, a DPF requires regeneration in order to keep the trapped matter from imposing excessive back-pressure on the engine. Regeneration involves creating conditions that will burn off trapped particulates whose unburned accumulation would otherwise eventually create excessive back-pressure. Such conditions may be created naturally as the engine operates, with the resulting regeneration being sometimes referred to as natural regeneration. Such conditions may also be created by a deliberate request for regeneration. The resulting regeneration is sometimes referred to as active regeneration.

[0003] A vehicle that is powered by an internal combustion engine whose exhaust system contains a DPF may operate over an extended period of time during which no regeneration of the DPF occurs. As trapped particulates accumulate, they impose increasing back-pressure on the engine.

[0004] It is known to use an engine control system to automatically initiate a regeneration request when the amount of trapped particulates reaches a level appropriate for regeneration. It is also known to provide a warning to the driver of the vehicle when the amount of trapped particulates reaches a level at which active regeneration is appropriate so that the driver can manually initiate an active regeneration, for example by operating a switch that issues a regeneration request to the engine control system.

SUMMARY OF THE INVENTION

[0005] One aspect of the invention relates to an engine comprising an exhaust system containing a diesel particulate filter (DPF) and timer-based warning structure for detecting and indicating particulate overloading of the DPF as the engine runs.

[0006] The warning structure comprises a) a source for providing data representing current particulate loading of the DPF, b) processing apparatus for i) repeatedly processing the current particulate loading data and data defining a threshold level of particulate loading at which a request for regeneration of the DPF should be issued, and ii) when a result of that processing discloses that the current particulate loading is at least as great as the threshold level, enabling an indicator, and iii) when processing of the current particulate loading data and data defining a hierarchy of zones of successively greater particulate overloading of the DPF takes place, wherein the threshold level discloses that the current particulate loading has remained in one of those zones for a length of time set by a timer, causing the enabled indicator to give an indication that the DPF has become overloaded.

[0007] Another aspect relates to an engine comprising an exhaust system containing a diesel particulate filter (DPF), and timer-based warning structure for detecting and indicating particulate overloading of the DPF as the engine runs.

[0008] The warning structure comprises a) a source for providing data representing current particulate loading of the DPF, b) processing apparatus for repeatedly processing the current particulate loading data and data defining a hierarchy of zones of successively greater particulate overloading of the DPF, wherein each zone comprises a range bounded by a respective lower level of particulate loading and a respective upper level of particulate loading, and c) the processing apparatus comprises, for each zone, an input stage for determining if the current particulate loading is greater than some level of loading, a timer that runs concurrently with the input stage disclosing that current particulate loading is greater than that level, and an output stage that issues a signal to indicate when the respective timer has disclosed that particulate loading has remained greater than that level for some set length of time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 shows portions of an engine and exhaust system relevant to the present invention in a motor vehicle.

[0011] FIG. 2 is chart showing various conditions related to the state of a DPF in the exhaust system.

[0012] FIGS. 3A and 3B collectively comprise a schematic illustration of a presently preferred embodiment of timer-based warning structure in accordance with principles of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0013] FIG. 1 shows a truck 10 that is propelled by a diesel engine 12. Engine 12 has one or more processors 14 that processes data from various sources to develop various data that is used for informational and/or control purposes. The data processed by control system 14 may originate at external sources, such as sensors, and/or be generated internally.

[0014] Engine 12 also has an exhaust system 16 through which exhaust created by combustion of a combustible mixture in combustion chambers of the engine is conveyed to a tail pipe 18 that opens to the surrounding atmosphere. Exhaust system 16 comprises one or more after-treatment devices, one of which is a diesel particulate filter (DPF) 20 that traps exhaust particulates (soot) so that they do not pass through to tail pipe 18.

[0015] As explained earlier, DPF 20 must be regenerated from time to time in order to burn off trapped particulates. When a need for regeneration is determined by a frequently executed algorithm in processor 14 disclosing that the particulate load in DPF 20 has reached a point where regeneration is required, a regeneration request is issued. If conditions are suitable for initiating regeneration, the engine control system may then automatically initiate regeneration, such as by changing fueling and/or air management, to suitably condition the exhaust. If conditions for regeneration are not suitable, regeneration is delayed, and particulates continue to accumulate in DPF 20 as engine 12 continues running. Some initial overloading of the DPF 20 is tolerable, but beyond that, the operator of truck 10 needs to be alerted.

[0016] The chart of FIG. 2 defines seven possible states for DPF 20: DPF missing; DPF leaking; DPF clean; DPF partly-loaded with soot; DPF loaded with soot to normal regenera-
tion trigger point; DPF overloaded with soot greater than normal regeneration trigger point; and DPF severely overloaded.

[0017] As shown by FIG. 2, each state has been defined in a processor 14 by a respective data value for a parameter STATE_EGBP_PF; using the numbers “7” through “1” inclusive in descending order.

[0018] Certain recommendations by the industry suggest that four levels of soot overloading (Service, Warning, Stop, Critical) be identified and made known in some way to the operator of a motor vehicle that has a DPF in its exhaust system. While the existing data values shown in FIG. 2 define important reference points for the amount of soot loading in DPF 20, they do not provide direct correspondence with the industry recommendations.

[0019] The present invention adapts the data values of FIG. 2 for use in conforming to industry recommendations.

[0020] A processor 14 processes data according to a time-based warning structure 30 shown in FIGS. 3A and 3B. The processed data comprises the current data value for parameter STATE_EGBP_PF and a selectable data value for each of eight parameters C_STATE_EGBP_PF1, C_STATE_EGBP_PF2, C_STATE_EGBP_PF3, C_STATE_EGBP_PF4, C_STATE_EGBP_PF5, C_STATE_EGBP_PF6, C_STATE_EGBP_PF7, and C_STATE_EGBP_PF8.

[0021] While the data values for the each of the latter eight parameters can be selected from any of the values “7” through “1” in FIG. 2, the use of only “2” and “1” is needed to conform to conform to industry recommendations.

[0022] Warning structure 30 comprises four sections 32, 34, 36, and 38 that function to detect and indicate a respective one of these four portions of the range of DPF soot loading greater than normal regeneration trigger point.

[0023] Section 32 is designated “Request Service” to correspond to “Service” of the industry recommendations; section 34, “Warn Level” to correspond to “Warning” of the industry recommendations; section 36, “Stop Level” to correspond to “Stop” of the industry recommendations; and section 38, “Severe Level” to correspond to “Critical” of the industry recommendations.

[0024] Each section 32, 34, 36, and 38 comprises a similar processing strategy that uses three comparison functions, an AND logic function, and a timer function. Two of the comparison functions and the AND logic function form an input stage, and the third comparison function forms an output stage to which the timer function is one input. The other input to the third comparison function is a parameter that sets the length of time that the timer must run in order for the output stage to issue a signal that the time has elapsed.

[0025] Section 32 comprises a comparison function 40 that compares the current value for STATE_EGBP_PF and the value of a parameter C_STATE_EGBP_PF1, and a comparison function 42 that compares the current value for STATE_EGBP_PF and the value of a parameter C_STATE_EGBP_PF2. When the amount of particulates in DPF 20 are within a range defined by C_STATE_EGBP_PF1 and C_STATE_EGBP_PF2, an AND logic function 44 enables a timer function 46 to run.

[0026] The running time on function 46 (parameter DPF_REQ_TIM) is compared with a reference time (parameter DPF_REQ_TIM) by a comparison function 48. When the running time exceeds the reference time, a signal represented by parameter REQ_DPF is given.

[0027] Section 34 comprises a comparison function 50 that compares the current value for STATE_EGBP_PF and the value of a parameter C_STATE_EGBP_PF3, and a comparison function 52 that compares the current value for STATE_EGBP_PF and the value of a parameter C_STATE_EGBP_PF4. When the amount of particulates in DPF 20 are within a range defined by C_STATE_EGBP_PF3 and C_STATE_EGBP_PF4, an AND logic function 54 enables a timer function 56 to run.

[0028] The running time on function 56 (parameter DPF_WARN_TIM) is compared with a reference time (parameter DPF_WARN_TIM) by a comparison function 58. When the running time exceeds the reference time, a signal represented by parameter WARN_DPF is given.

[0029] Section 36 comprises a comparison function 60 that compares the current value for STATE_EGBP_PF and the value of a parameter C_STATE_EGBP_PF5, and a comparison function 62 that compares the current value for STATE_EGBP_PF and the value of a parameter C_STATE_EGBP_PF6. When the amount of particulates in DPF 20 are within a range defined by C_STATE_EGBP_PF5 and C_STATE_EGBP_PF6, an AND logic function 64 enables a timer function 66 to run.

[0030] The running time on function 66 (parameter DPF_STOP_TIM) is compared with a reference time (parameter DPF_STOP_TIM) by a comparison function 68. When the running time exceeds the reference time, a signal represented by parameter STOP_DPF is given.

[0031] Section 38 comprises a comparison function 70 that compares the current value for STATE_EGBP_PF and the value of a parameter C_STATE_EGBP_PF7, and a comparison function 72 that compares the current value for STATE_EGBP_PF and the value of a parameter C_STATE_EGBP_PF8. When the amount of particulates in DPF 20 are within a range defined by C_STATE_EGBP_PF7 and C_STATE_EGBP_PF8, an AND logic function 74 enables a timer function 76 to run.

[0032] The running time on function 76 (parameter DPF_SEV_TIM) is compared with a reference time (parameter DPF_SEV_TIM) by a comparison function 78. When the running time exceeds the reference time, a signal represented by parameter SEVERE_DPF is given.

[0033] Parameter REQ_DPF is an input to a switch function 80 that is used to operate an indicator shown as a lamp 82. The state of switch function 80, either OFF or ON, is controlled by a parameter DPF_STATE that is provided by the output of an OR logic function 84 to which parameters WARN_DPF, STOP_DPF, and SEVERE_DPF are inputs. The latter two parameters are also inputs to an OR logic function 86.

[0034] The four sections 32, 34, 36, and 38 enable the conditions that start the respective timers and the length of time that each timer will run before giving a signal at a respective output to be set as deemed appropriate for a particular vehicle and/or engine.

[0035] By selecting from “DPF overloaded with soot greater than normal regeneration trigger point” (“2”) and “DPF severely overloaded” (“1”), in conjunction with SELECTING values for DPF_REQ_TIM, DPF_WARN_TIM, DPF_STOP_TIM, and DPF_SEV_TIM, it is possible to conform to the industry recommendations for alerting the operator.

[0036] In one example, a selection of STATE_EGBP_PF=2 for both C_STATE_EGBP_PF1 and C_STATE_EGBP_PF2, and a value of ten minutes for DPF_REQ_TIM will cause REQ_DPF to enable switch function 80 ten minutes after a regeneration request has been issued and the engine continues running without any active regeneration having commenced.
[0037] A selection of STATE_EGBP_PF=2 for both C_STATE_EGBP_PF_3 and C_STATE_EGBP_PF_4, and a value of sixty minutes for DPF_WARN_LVL_TM will cause WARN_DPF to switch function 80 to ON state after sixty minutes of continued running of the engine without any active regeneration having commenced after the regeneration request. With switch function 80 both enabled and operated, lamp 82 lights to give a warning to the vehicle operator.

[0038] A selection of STATE_EGBP_PF=1 for both C_STATE_EGBP_PF_5 and C_STATE_EGBP_PF_6, and a value of five minutes for DPF_STOP_LVL_TM will cause the state of STOP_DPF_DERATE_LVL_1 to change. If timer function 46 is kept from being reset, STOP_DPF_DERATE_LVL_1 will continue to keep switch function 80 in the ON state via OR logic function 84 five minutes after the change in STATE_EGBP_PF from “2” to “1”. It also causes the engine control system to de-rate engine 12. To indicate the continued lack of regeneration, STOP_DPF_DERATE_LVL_1 will also illuminate a second lamp 88 via OR logic function 86.

[0039] A selection of STATE_EGBP_PF=1 for both C_STATE_EGBP_PF_7 and C_STATE_EGBP_PF_8, and a value of thirty minutes for DPF_SEVERE_LVL_TM will cause SEVERE_DPF_DERATE_LVL_2 to continue to keep switch function 80 ON via OR logic function 84 thirty minutes after the change in STATE_EGBP_PF from “2” to “1”. It will also de-rate the engine even more severely than did STOP_DPF_DERATE_LVL_1 and will continue to illuminate lamp 88.

[0040] While a presently preferred embodiment of the invention has been illustrated and described, it should be appreciated that principles of the invention apply to all embodiments falling within the scope of the invention that is defined as follows.

What is claimed is:

1. An engine comprising:
an exhaust system containing a diesel particulate filter (DPF),
and timer-based warning structure for detecting and indicating particulate overloading of the DPF as the engine runs, the warning structure comprising,
a) a source for providing data representing current particulate loading of the DPF,
b) processing apparatus for i) repeatedly processing the current particulate loading data and data defining a threshold level of particulate loading at which a request for regeneration of the DPF should be issued, and ii) when a result of that processing discloses that the current particulate loading is at least as great as the threshold level, enabling an indicator, and iii) when processing of the current particulate loading data and data defining a hierarchy of zones of successively greater particulate overloading of the DPF greater than the threshold level discloses that the current particulate loading has remained in one of those zones for a length of time set by a timer, causing the enabled indicator to give an indication that the DPF has become overloaded.

2. An engine as set forth in claim 1 wherein the data defining a hierarchy of zones defines first, second, and third zones of successively greater particulate overloading in that order, and the first zone has a lower limit equal to the threshold level.

3. An engine as set forth in claim 2 wherein when processing of the current particulate loading data and data defining the hierarchy of zones discloses that current particulate loading has remained in the second zone for a length of time set by a timer, the processing apparatus issues an engine de-rate request to an engine control strategy for de-rating the engine.

4. An engine as set forth in claim 3 wherein when processing of the current particulate loading data and data defining the hierarchy of zones discloses that current particulate loading has remained in the third zone for a length of time set by a timer, the processing apparatus issues an engine de-rate request that is more extreme than the de-rate request issued in consequence of particulate loading remaining in the second zone.

5. An engine comprising:
an exhaust system containing a diesel particulate filter (DPF);
and timer-based warning structure for detecting and indicating particulate overloading of the DPF as the engine runs, the warning structure comprising,
a) a source for providing data representing current particulate loading of the DPF,
b) processing apparatus for repeatedly processing the current particulate loading data and data defining a hierarchy of zones of successively greater particulate overloading of the DPF, wherein each zone comprises a range bounded by a respective lower level of particulate loading and a respective upper level of particulate loading, and
c) the processing apparatus comprises, for each zone, an input stage for determining if the current particulate loading is greater than some level of loading, a timer that runs concurrently with the input stage disclosing that current particulate loading is greater than that level, and an output stage that issues a signal to indicate when the respective timer has disclosed that particulate loading has remained greater than that level for some set length of time.

6. An engine as set forth in claim 5 wherein each input stage comprises two comparison functions and an AND logic function that processes outputs of the AND logic function.

7. An engine as set forth in claim 5 wherein each output stage comprises a comparison function to which the timer is one input and to which a parameter for setting the respective length of time that the respective timer must run in order for the output stage to issue the respective signal is another input.

8. An engine as set forth in claim 5 further including one or more indicators that are operated by signals from one or more output stages.

9. An engine as set forth in claim 8 wherein the one or more indicators comprise lamps that disposed for viewing by an operator of a motor vehicle containing the engine.

10. An engine as set forth in claim 5 further including an engine control system, and wherein respective signals from certain output stages cause the control system to de-rate the engine to respective de-rate levels.

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