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(54) Title: REDUCTANT QUALITY SENSOR

(57) Abstract: A control system for reducing nitrogen oxides in engine exhaust includes an emissions catalyst having an inlet adapted to receive an exhaust from the engine. A reductant tank is configured to store a reductant. An injector is in fluid communication with the reductant tank and is operable to inject the reductant into the exhaust upstream of the catalyst. A sensor is in fluid communication with the reductant and outputs a reductant quality signal based on the reductant. A controller determines a reductant quality of the reductant based on the reductant quality signal and outputs a dosing rate signal based on the reductant quality. The injector alters a dosing rate of the reductant based on the dosing signal.



REDUCTANT QUALITY SENSOR

FIELD

[0001] The present disclosure relates generally to exhaust treatment systems and, more particularly, relates to a reductant quality sensor in an exhaust treatment system and related method for determining a quality of the reductant.

BACKGROUND

[0002] Selective catalytic reduction technology has been used in conjunction with reducing nitrogen oxides present in the exhaust of internal combustion engines. Many vehicles utilizing internal combustion engines as a prime mover are also equipped with exhaust after-treatment devices for reducing nitrogen oxide emissions. Some of these systems are constructed using urea-based technology including a separate container mounted to the vehicle for storing the urea, a urea injector and a selective catalytic reduction catalyst. While these systems may have performed well in the past, it may be desirable to provide a selective catalytic reduction system operable without the use of urea or other reductants not typically onboard a vehicle.

SUMMARY

[0003] This section provides a general summary of the disclosure, and is not a comprehensive disclosure of its full scope or all of its features.

[0004] A control system for reducing nitrogen oxides in engine exhaust includes an emissions catalyst having an inlet adapted to receive an exhaust from the engine. A reductant tank is configured to store a reductant. An injector is in fluid communication with the reductant tank and is operable to inject the reductant into the exhaust upstream of the catalyst. A sensor is in fluid communication with the reductant and outputs a reductant quality signal based on the reductant. A controller determines a reductant quality of the reductant based on the reductant quality signal and outputs a dosing rate signal based on

the reductant quality. The injector alters a dosing rate of the reductant based on the dosing signal.

[0005] According to other features, the reductant quality comprises an ethanol content of the reductant. The controller outputs a signal to a driver information display based on a determined ethanol content that is outside of a predetermined range. According to one feature, the dosing rate signal corresponds to an increased reductant dosing rate for a determined ethanol content that is below a predetermined value. According to another feature, the dosing rate signal corresponds to a reduced reductant dosing rate for a determined ethanol content this is above a predetermined value. The controller determines the reductant quality based on a reductant volume increase in the reductant tank. The reductant can comprise a fuel including one of E85, E95, B5, B10 and B20.

[0006] A method for reducing nitrogen oxides in an exhaust system of an engine includes injecting a reductant into an exhaust conduit that passes the exhaust stream. A quality of the reductant is determined. A dosing rate is determined based on the quality. A dosing signal is communicated to the injector based on the dosing rate. The dosing rate of the reductant is altered based on the dosing signal. Determining the quality of the reductant comprises communicating a reductant quality signal from a sensor in fluid communication with the reductant to a controller. An ethanol content of the reductant is determined based on the reductant quality signal. Altering the dosing rate of the reductant according to one feature includes communicating a dosing rate signal to an injector that is in fluid communication with the reductant and the exhaust conduit. The reductant is injected into the exhaust conduit based on the dosing rate signal. According to other features, altering the dosing rate of the reductant includes increasing the dosing rate in response to a determined ethanol content that is below a predetermined value. The dosing rate of the reductant is decreased in response to a determined ethanol content that is above a predetermined value.

[0007] According to other features, a fault signal is communicated to a driver information display based on the determined ethanol content being outside

of a predetermined range. A volume of reductant in a reductant tank is determined. The ethanol content of the reductant is determined based on an increase in reductant volume above a threshold.

[0008] Further areas of applicability will become apparent from the description provided herein. The description and specific examples in this summary are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

DRAWINGS

[0009] The drawings described herein are for illustrative purposes only
10 of selected embodiments and not all possible implementations, and are not
intended to limit the scope of the present disclosure.

[0010] Figure 1 is a schematic view of a control system for reducing nitrogen oxides in an engine exhaust on a vehicle;

[0011] Figure 2 is a schematic view of an emissions system according to additional features of the present teachings that incorporates multiple reductants;

[0012] Figure 3 is a schematic view of an emissions system according to additional features that incorporates multiple reductants and having two distinct reductant delivery lines; and

20 **[0013]** Figure 4 is a functional block diagram of a control system that reduces nitrogen oxides in an exhaust stream of an engine of a vehicle.

[0014] Corresponding reference numerals indicate corresponding parts throughout the several views of the drawings.

25 DETAILED DESCRIPTION

[0015] Example embodiments will now be described more fully with reference to the accompanying drawings.

[0016] Figure 1 depicts an emissions control system 10 associated with an exemplary vehicle 12. The vehicle 12 includes an engine 14 arranged as a prime mover and having an exhaust port 16 that is in fluid communication with an exhaust conduit 18. An engine exhaust stream 20 flows from the engine 14 through the exhaust conduit 18. An injector 22 is positioned to inject a reductant

into the exhaust stream 20 flowing through the exhaust conduit 18. An emissions catalyst 24 having an inlet 26 and an outlet 28 is positioned downstream of the injector 22 and is in receipt of the exhaust stream 20 that is flowing through the exhaust conduit 18.

5 **[0017]** A fuel tank 30 is mounted to the vehicle 12 to store fuel. The fuel tank 30 is in fluid communication with the engine 14 via a fuel supply line 32 such that fuel may be selectively supplied to combustion chambers of the engine 14. It is contemplated that the engine 14 may be a gasoline fueled spark ignition engine or may be a diesel fueled compression engine. Fuels for the gasoline
10 engine may include gasoline, E85, E95 or other similar fuels. Fuels for the diesel engine may include diesel fuel, bio fuel B5, B10, B20 or other similar fuels. A supplemental reductant tank 40 is also mounted to the vehicle 12. It is contemplated that the tank 40 may store a readily available reductant such as E85, E95, B5, B10, B20 or the like. In one example, a user can fill the tank 40
15 by conventional methods such as by dispensing reductant through a filler neck (not specifically shown) that fluidly connects with the fill tank 40. A reductant level sensor 42 is provided in the reductant tank 40 and communicates a reductant volume signal 44 to a controller 50. A reductant line 52 fluidly connects the reductant tank 40 to the injector 22. The reductant line 52 is
20 configured to fluidly communicate the reductant from the reductant tank 40 to the injector 22 as will be described herein. An optional recirculation line 54 may be used to allow high injection pressures and/or maintain reductant flow.

[0018] A reductant quality sensor 56 is in fluid communication with the line 52. The reductant quality sensor 56 is configured to communicate a
25 reductant quality signal 58 to the controller 50. According to one configuration of the present teachings, the controller 50 is configured to determine an ethanol content of the reductant based on the reductant quality signal 58. The ethanol content can be determined in a number of ways such as, but not limited to, a lookup table. Controller 50 determines a dosing rate based on the determined
30 ethanol content. Moreover, the controller 50 can be any module and/or device including an application specific integrated circuit (ASIC), an electronic circuit, a processor (shared, dedicated, or group) and memory that execute one or more

software or firmware programs, a combinational logic circuit, or other suitable components that provide the described functionality. The controller 50 communicates a dosing rate signal 60 to the injector 22 based on the determined ethanol content.

5 **[0019]** As can be appreciated, it is desirable to conserve reductant while dosing only the necessary amount into the exhaust conduit 18. The effectiveness of the reductant, and ultimately the emissions control system as a whole, is related to the ethanol content of the reductant. For various reasons, such as reductant source, inconsistencies of the emissions control system
10 and/or the environment, the ethanol content of the reductant in the tank 40 may vary. In this regard, the reductant quality sensor 56 and the controller 50 determine the ethanol content and deliver, by way of the injector 22, the minimum effective dosing rate of reductant into the exhaust conduit 18.

[0020] A plurality of supplemental sensors 62 may be in
15 communication with the controller 50. The dosing rate signal 60 can be further based on an evaluation of vehicle data in various combinations with the determined ethanol content of the reductant. The sensors 62 may provide signals indicative of, but not limited to, engine speed, engine operating temperature, exhaust temperature, mass air flow, diesel fuel volume within tank
20 30, NO_x concentration, HC concentration, O₂ concentration, H₂ concentration, ammonia concentration and other data that may be available from a CAN bus or dedicated sensors mounted to the vehicle 12.

[0021] In this regard, the controller 50 communicates the dosing rate signal 60 to selectively operate the injector 22. The injector 22 supplies the
25 reductant flowing through the line 52 based on the input provided from the reductant quality signal 58, reductant level sensor 42, and sensors 62. The controller 50 communicates a status signal 68 to a driver information display 70. The status signal 68 can correspond to various information determined by the controller 50 such as, but not limited to, a fault with the emissions control system
30 10, an ethanol content of the reductant, a dosing rate of the injector 22, and a reductant level of the reductant tank 40 or other information related to the emissions control system 10. It is also contemplated that the status signal 68

can also be communicated in conjunction with the emissions control system being disabled by the controller 50.

[0022] Turning now to Figure 2, an alternate emissions control system 100 will be described. The emissions control system 100 is similar to the emissions control system 10 described above. Accordingly, like elements will retain their previously introduced referenced numerals. A supply line 102 extends from the fuel tank 30 to a valve 104. The valve 104 selectively interconnects the injector 22 with one or both of the fuel tank 30 and the supplemental reductant tank 40. More particularly, the supply line 102 extends from the fuel tank 30 to a first inlet port 106 of the valve 104. In a similar fashion, a second supply line 110 interconnects the reductant tank 40 and a second inlet port 112 of the valve 104.

[0023] The controller 50 is operable to control the valve 104 to selectively supply reductant to the injector 22. The controller 50 may cause the valve 104 to solely provide fuel from the tank 30 to the injector 22. Depending on the conditions present, fuel in the fuel tank 30 may act as a suitable reductant. The controller 50 may also control the valve 104 to solely supply the reductant stored within the reductant tank 40 to the injector 22. The controller 104 may simultaneously provide fuel and a supplemental reductant to the injector 22 at one of any number of mixing ratios between 0-100%.

[0024] Figure 3 depicts an alternate emissions control system 200. The emissions control system 200 is similar to the emissions control systems 10 and 100. Accordingly, like elements will retain their previously introduced reference numerals. In the configuration shown in Figure 3, a fuel supply line 202 interconnects the fuel tank 30 and a fuel injector 204. The fuel injector 204 is operable to selectively supply fuel as a reductant to the engine exhaust stream 20 in the exhaust conduit 18. The supply of fuel into the exhaust stream 20 is controlled by way of a fuel signal 206 communicated by the controller 50.

[0025] Another supply line 210 interconnects the reductant tank 40 with the injector 22. The injector 22 is selectively operable to inject the reductant contained within the reductant tank 40 into the exhaust stream 20 passing

through the exhaust conduit 18 as described above with respect to the control systems 10 and 100.

[0026] Turning now to Figure 4, steps for reducing nitrogen oxides in the exhaust stream 20 of the engine 14 are shown generally at 300. Control begins with step 302. In step 304, control determines if the engine 14 has started. If the engine 14 has started, control determines an ethanol content of the reductant at step 310. If the engine 14 has not started, control determines if a reductant fill has occurred in step 308. Control can determine if a reductant fill occurred based on the level sensor signal 44 communicated from the reductant tank 40 to the controller 50. If a reductant fill has occurred, control determines an ethanol content of the reductant at step 310. If a reductant fill has not occurred, control loops to step 304.

[0027] In step 312, control determines if the ethanol content is within a predetermined range. If the ethanol content is not within a predetermined range, control notifies the driver in step 314. In one example, control sends the driver information signal 68 to the driver display 70. Again, such notification can include a fault signal in the form of a telltale and/or audible signal. The notification can also occur in conjunction with the controller 50 disabling the emissions control system 10. Control then ends in step 320.

[0028] If the ethanol content is within a predetermined range, control determines the reductant dosing rate based on further comparisons. More specifically, control determines whether the ethanol content is greater than a predetermined upper threshold in step 322. If the ethanol content is greater than the upper threshold, control reduces the reductant dosing rate in step 324. The engine is started at step 332 if the engine is not already running. Dosing begins in step 326. If the ethanol content is not greater than the upper threshold, control determines if the ethanol content is less than a predetermined lower threshold in step 328. If the ethanol content is less than the lower threshold in step 328, control increases the reductant dosing rate in step 330 and begins dosing in step 326. If the ethanol content is between the upper and lower thresholds, dosing at a predetermined dosing rate occurs at step 326. According to one example, an ethanol content less than 50% of total reductant volume

would pass through decision block 312 as being within the predetermined ethanol range. This level of reductant would be lower than the lower threshold and therefore cause control to increase the dosing rate. Other percentages are contemplated.

5 **[0029]** Alternatively, the ethanol content thresholds may be replaced with a look-up table or an algorithm where control would set the dosing rate based on the determined reductant content. Control ends at step 320. It is contemplated that control may alternatively loop to step 304 to provide a continuous monitoring of the reductant quality.

10 **[0030]** The foregoing description of the embodiments has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the disclosure. Individual elements or features of a particular embodiment are generally not limited to that particular embodiment, but, where applicable, are interchangeable and can be used in a selected
15 embodiment, even if not specifically shown or described. The same may also be varied in many ways. Such variations are not to be regarded as a departure from the disclosure, and all such modifications are intended to be included within the scope of the disclosure.

CLAIMS

What is claimed is:

1. A control system for reducing nitrogen oxides in engine exhaust,
5 the system comprising:
 - an emissions catalyst having an inlet adapted to receive an exhaust from the engine;
 - a reductant tank to store a reductant;
 - an injector in fluid communication with the reductant tank and
10 operable to inject the reductant into the exhaust upstream of the catalyst;
 - a sensor in fluid communication with the reductant and that outputs a reductant quality signal based on a composition of the reductant; and
 - a controller that determines a reductant quality of the reductant based on the reductant quality signal and that outputs a dosing rate signal based
15 on the reductant quality;wherein the injector injects the reductant at a dosing rate based on the dosing rate signal.
2. The control system of claim 1 wherein the reductant quality
20 comprises an ethanol content of the reductant.
3. The control system of claim 2 wherein the controller outputs a signal to a driver information display based on a determined ethanol content that is outside of a predetermined range.
25
4. The control system of claim 2 wherein the dosing rate signal corresponds to an increased reductant dosing rate for a determined ethanol content that is below a predetermined value.
5. The control system of claim 2 wherein the dosing rate signal
30 corresponds to a reduced reductant dosing rate for a determined ethanol content that is above a predetermined value.

6. The control system of claim 1 wherein the controller determines the reductant quality based on a reductant volume increase in the reductant tank.

7. The control system of claim 1 wherein the reductant comprises a fuel including one of E85, E95, B5, B10 and B20.

8. A method for reducing nitrogen oxides in an exhaust stream of an engine, the method comprising:

injecting a reductant through an injector and into an exhaust conduit that passes the exhaust stream;
determining a quality of the reductant;
determining a dosing rate based on the quality;
communicating a dosing signal to the injector based on the dosing rate; and
altering the dosing rate of the reductant based on the dosing signal.

9. The method of claim 8 wherein determining the quality of the reductant comprises:

communicating a reductant quality signal from a sensor in fluid communication with the reductant to a controller; and
determining an ethanol content of the reductant based on the reductant quality signal.

10. The method of claim 9 wherein altering the dosing rate of the reductant comprises:

communicating a dosing rate signal to an injector that is in fluid communication with the reductant and the exhaust conduit; and
injecting reductant into the exhaust conduit based on the dosing rate signal.

11. The method of claim 10 wherein altering the dosing rate of the reductant comprises:

increasing the dosing rate in response to a determined ethanol content below a predetermined value.

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12. The method of claim 10 wherein altering the dosing rate of the reductant comprises:

decreasing the dosing rate in response to a determined ethanol content above a predetermined value.

10

13. The method of claim 9 further comprising:

communicating a fault signal to a driver information display based on the determined ethanol content being outside of a predetermined range.

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14. The method of claim 9, further comprising:

determining a volume of reductant in a reductant tank; and
determining the ethanol content of the reductant based on a determination of an increase in reductant volume above a threshold.

20

15. The method of claim 9, further comprising:

determining whether the engine has started; and
determining the ethanol content of the reductant based on a determination that the engine has started.

25

16. The method of claim 8 wherein injecting the reductant comprises:

injecting a fuel including one of E85, E95, B5, B10 and B20.

17. A method for reducing nitrogen oxides in an exhaust stream of an engine, the method comprising:

30

determining an ethanol content of the reductant;
communicating a fault signal to a driver information display based on the determined ethanol content being outside of a predetermined range;

and

injecting a reductant with an injector into an exhaust conduit that passes the exhaust stream based on the ethanol content being within the predetermined range;

5 communicating a dosing rate signal to the injector that is in fluid communication with the reductant and the exhaust conduit;

 increasing the dosing rate of the reductant injected by the injector in response to a dosing rate signal corresponding to an ethanol content below a predetermined value; and

10 decreasing the dosing rate of the reductant injected by the injector in response to a dosing rate signal corresponding to an ethanol content above a predetermined value.

18. The method of claim 17, further comprising:

15 determining a volume of reductant in a reductant tank; and

 determining the ethanol content of the reductant based on a determination of an increase in reductant volume above a threshold.

19. The method of claim 17, further comprising:

20 determining whether the engine has started; and

 determining the ethanol content of the reductant based on a determination that the engine has started.

20. The method of claim 17 wherein injecting the reductant comprises:

25 injecting a fuel including one of E85, E95, B5, B10 and B20.

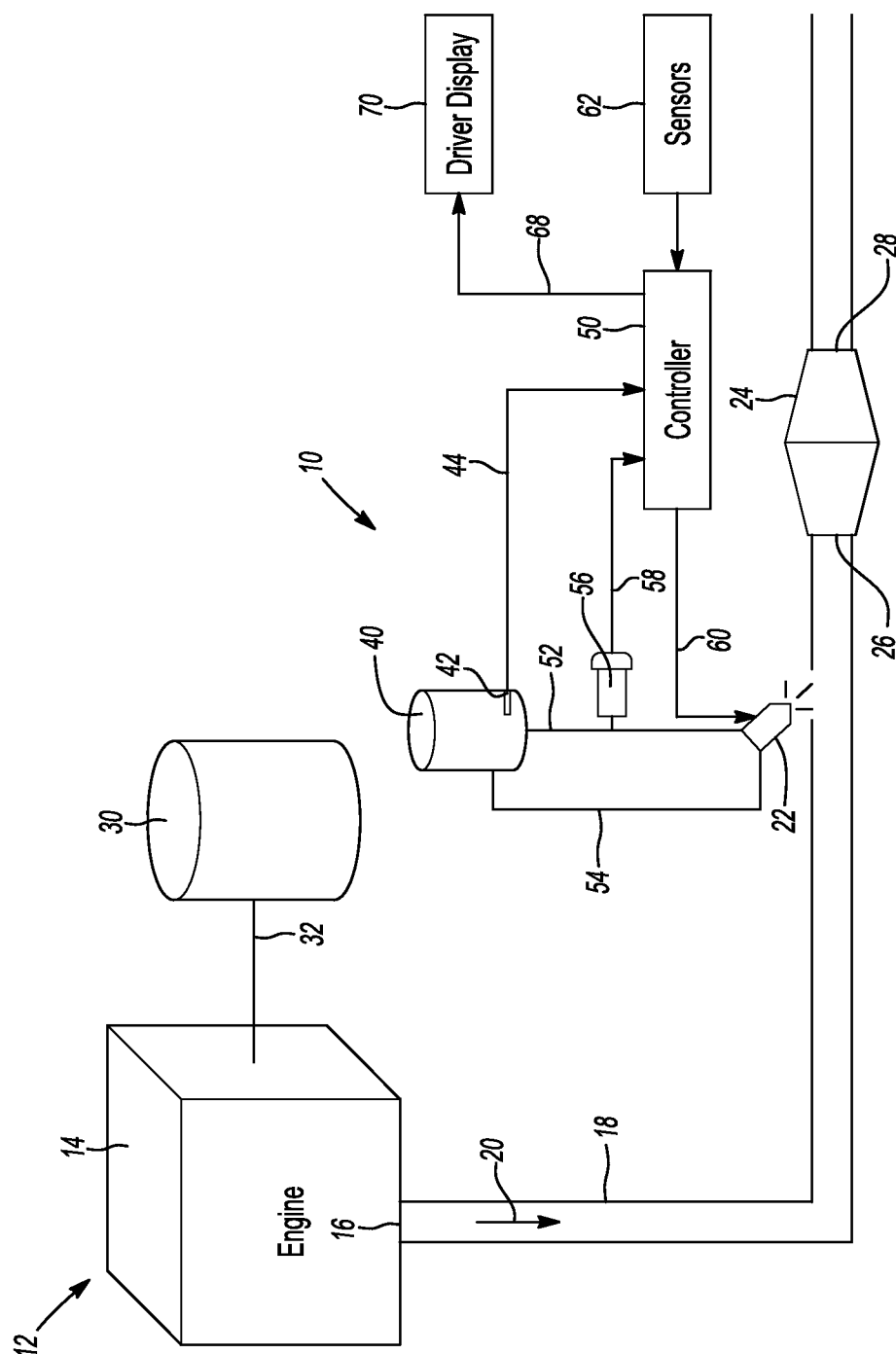


Fig-1

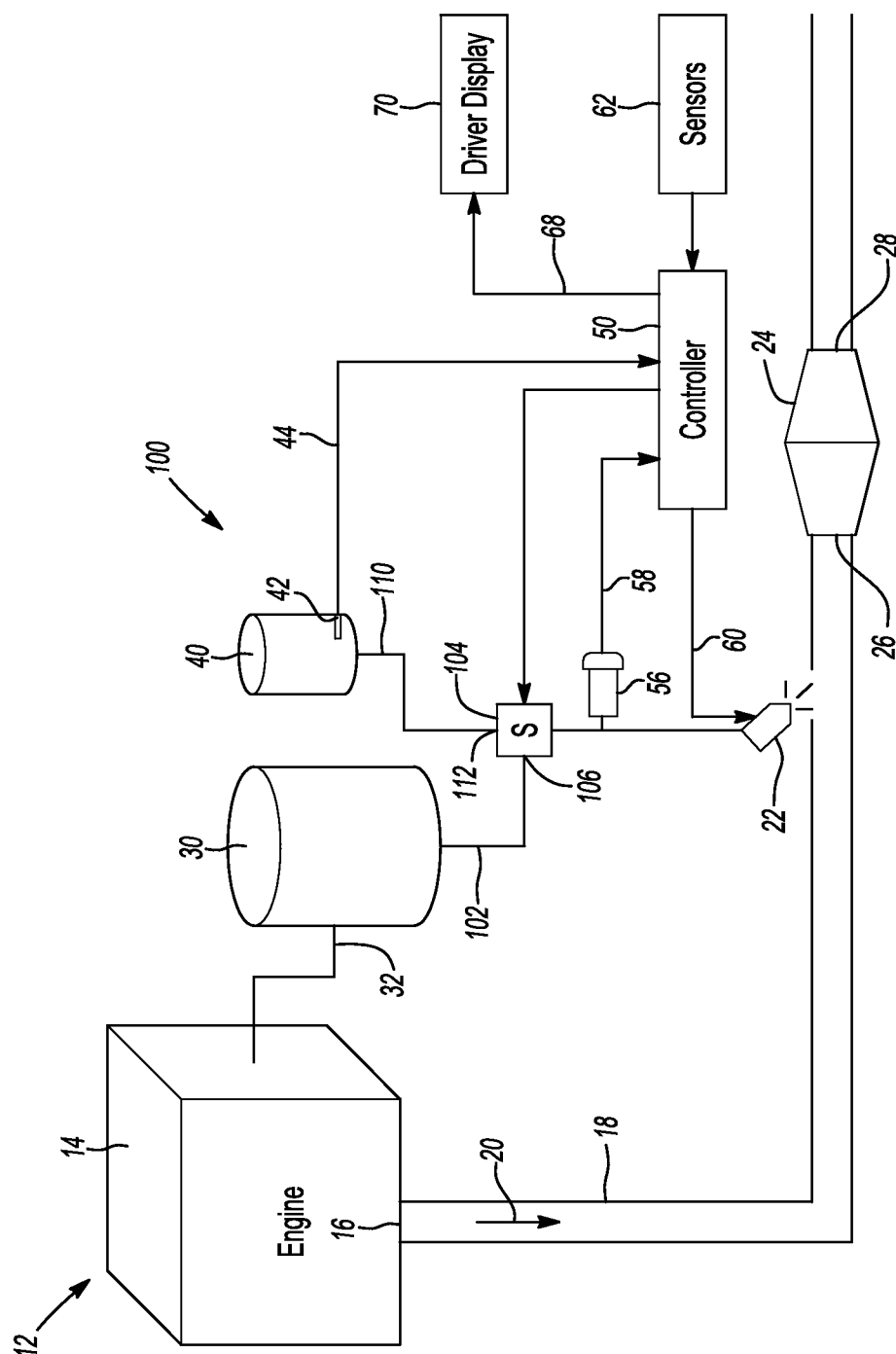


Fig-2

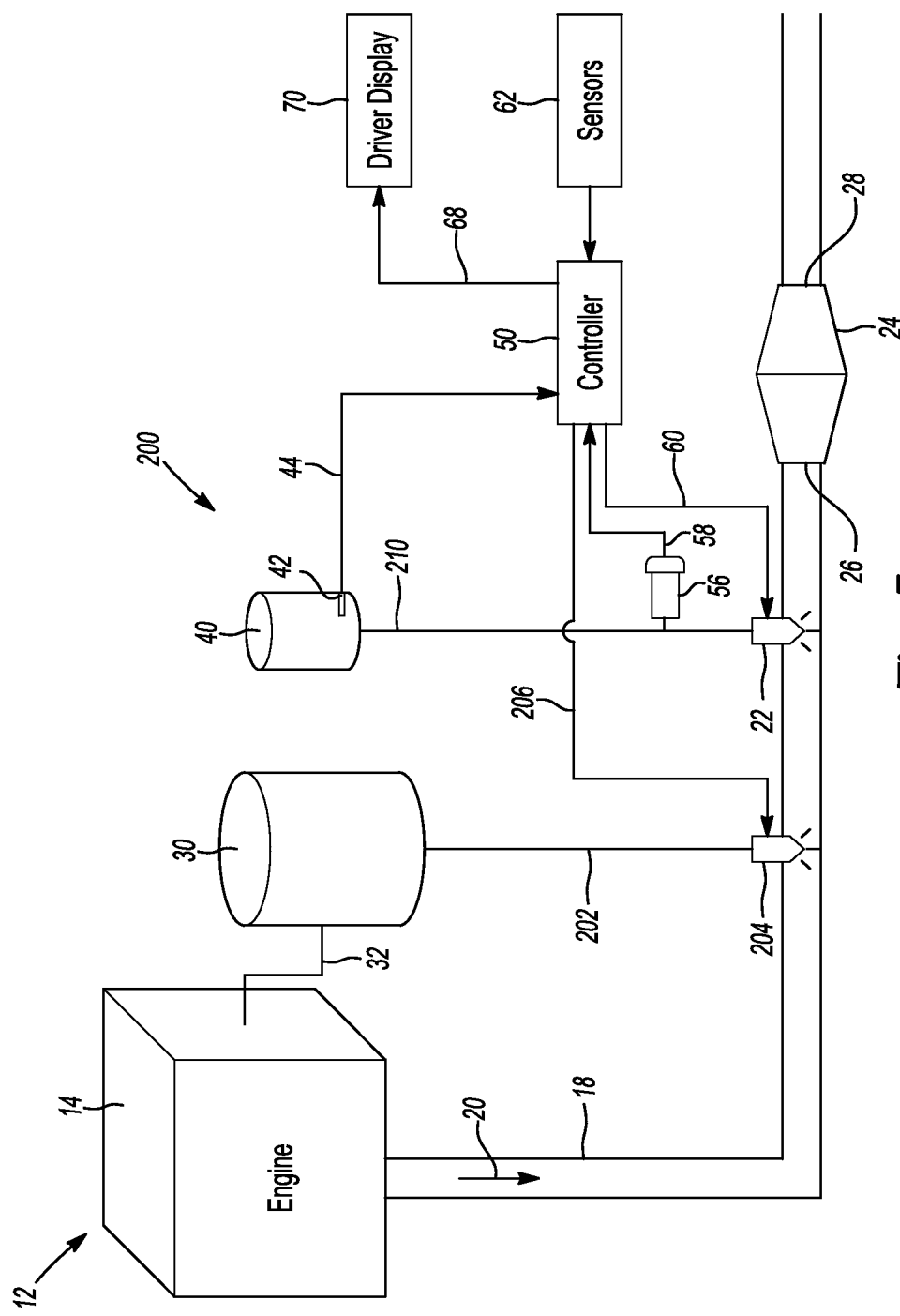
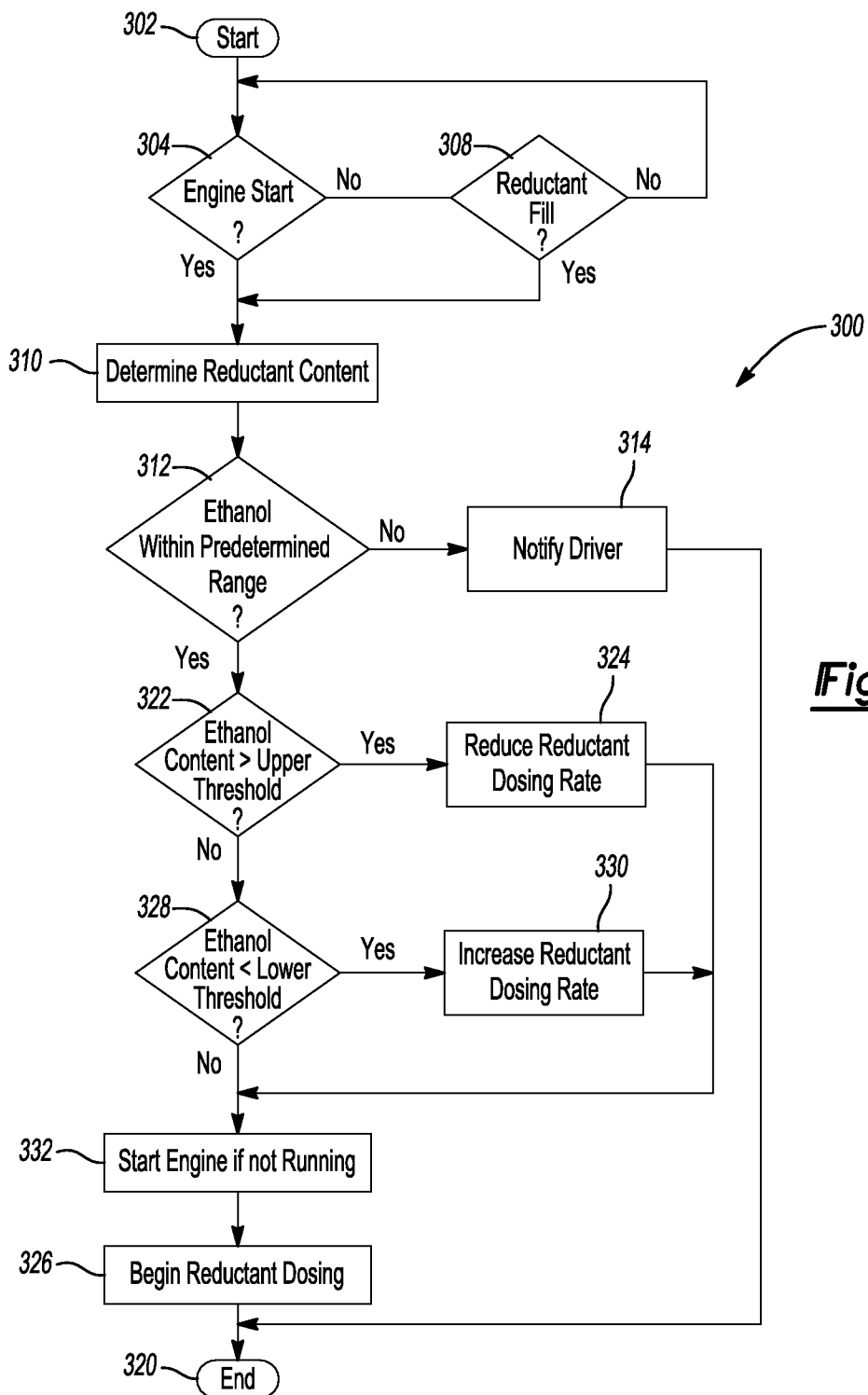


Fig-3

**Fig-4**