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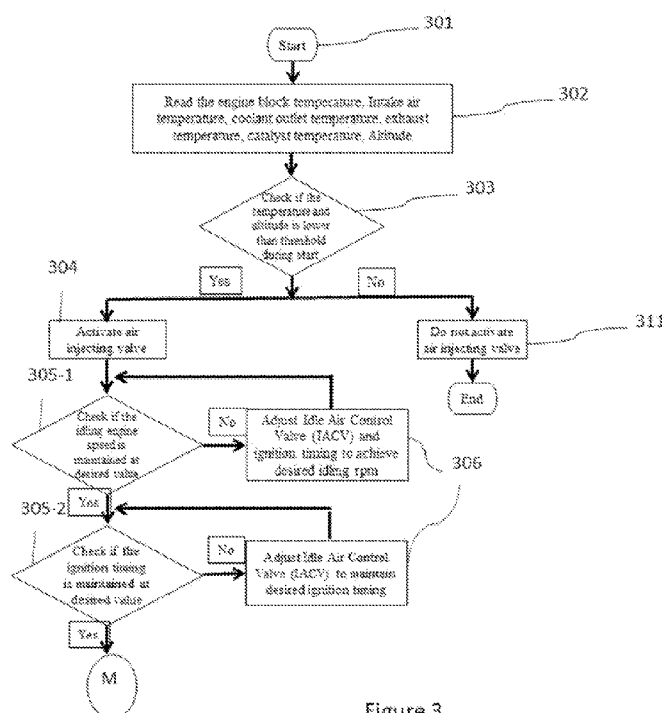


Figure 3

(57) Abstract: The present subject matter, in general, relates to a method for controlling an exhaust system capable of being implemented in a vehicle with two or more wheels including an internal combustion engine and, in particular relates to a combustion gas-exhaust system for the internal combustion engine of the vehicle. The method is performed by an controller (205) to control the air injection valve (204) by receiving one or more inputs from one or more sensors (206, 207, 208, 209, 212). The method is employed to reduced THC emission during cold start of the engine.

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AN EXHAUST CONTROL SYTEM

TECHNICAL FIELD

[0001] The present subject matter, in general, relates to a vehicle with two or more wheels and including an internal combustion engine. More particularly, but not
5 exclusively, the present subject matter relates to an exhaust control system and one or more methods for controlling the exhaust control system capable of being implemented in the vehicle with two or more wheels.

BACKGROUND

[0002] Generally, motor vehicles like two or three wheeled type vehicles are
10 provided with an internal combustion (IC) engine unit. These vehicles may constitute two-wheels or three-wheels depending on application, engine layout etc. Some of these vehicles are provided with a swinging-type engine, and a connecting link, like a toggle link, is provided to support the IC engine unit. Some other type of vehicles has the IC engine fixedly mounted to the frame. Moreover, the exhaust
15 system has to perform optimally in order to treat exhaust gases without any failure of the system even under severe usage conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The detailed description is described with reference to an embodiment of
20 a scooter type two wheeled vehicle along with the accompanying figures. The same numbers are used throughout the drawings to reference like features and components.

[0004] Figure 1 depicts a right-side view of an exemplary motor vehicle, in accordance with an embodiment of the present subject matter.

25 [0005] Figure 2 illustrates a block diagram of an exhaust control system according to an embodiment of the present invention.

[0006] Figure 3 illustrates a first embodiment of the present invention, the exhaust control system is controlled by a first method.

[0007] Figure 4 illustrates a method to control an exhaust system according to a
30 second embodiment.

[0008] Figure 5 shows a conventional characteristic curve depicting the THC emission traces of a typical vehicle Fig. 6 illustrates a front view of a portion of the exhaust pipe of the exhaust system of the vehicle.

[0009] Figure 6 shows the cumulative effect of activating E-SAI valve.

- 5 [00010] Figure 7 shows the comparison between base THC emission and E-SAI optimized THC emission.

DETAILED DESCRIPTION

[00011] Conventionally, motor vehicles are provided with a drive means including the internal combustion (IC) engine and/or a traction motor. Also, the
10 vehicle includes various sub-systems like an air induction system that works in conjunction with a fuel supply system like a carburetor or a fuel injector. Air-fuel mixture is supplied to the IC engine for combustion, which produces desired power and torque that is transferred to at least one wheel of the vehicle. Further, the gas exhaust system includes exhaust pipe that transmits the gases generated during
15 combustion process to a muffler. Generally, the gases that are produced may include various harmful components including total hydrocarbons (THC), carbon monoxide (CO), and nitrogen oxides (NO_x). An efficient and optimal combustion process achieves good engine performance with negligible exhaust. Thus, improving performance of the engine is always a desired objective which also
20 results in reduced emissions. However, for the gas formed from combustion process, there is a need for treating its harmful components prior to emitting the gases into the atmosphere through the muffler. Typically, a gas treatment device is used for treatment of the aforementioned harmful components before emitting to the atmosphere. The known exhaust pipe/discharge pipe has to accommodate the
25 treatment device securely. The exhaust pipe should also be capable of accommodating a sensor unit for detecting the amount of oxygen content in the emitted exhaust gases.

[00012] Typically, in known vehicles powered by internal combustion engines, secondary air injection (SAI) is provided to the exhaust pipe. For example,
30 whenever there is a requirement of richer air-fuel mixture during cold start and warm-up, i.e., when the engine block temperature < 60°C zone and in order to

nullify the effect of wall wetting, there is a need for providing secondary air injection (SAI) to the exhaust pipe. In order to provide SAI, air from the post-filter volume of the air cleaner is tapped by using a valve, called as the air injecting valve, and supplied to the exhaust pipe, generally in a region before the exhaust gases
5 reaches the catalytic converter. The air from the post-filter volume is tapped whenever a difference in pressure occurs between the exhaust port and the inlet of the valve. Such a SAI helps in increasing the temperature of the exhaust gases exiting out of the exhaust port to a greater extent, which also enables early light-off of the catalytic converter. Typically, the exhaust gas temperature increases
10 whenever an exothermic reaction occurs in the exhaust passage, which is due to oxidation of unburnt hydrocarbons in the exhaust passage.

[00013] However, such a mechanically operated SAI cannot be controlled, as secondary air injection happens whenever a pressure difference exists. Such uncontrolled SAI may lead to damage of the catalytic converter, as increase in
15 temperature of exhaust gases is typically required only during cold starting or sub-optimal temperature conditions of the engine. Frequently increasing the temperature of exhaust gases may lead to increase in NO_x emission due to excess supply of air through SAI. Moreover, whenever misfiring occurs, for example, during low throttle conditions, deceleration and sudden acceleration, the supply of
20 air-fuel mixture ratio is richer, which causes undesirable reaction in the catalytic converter, which also leads to damage of catalytic converter.

[00014] Thus, there is a need for controlling the operation of secondary air injection, in particular, the opening and closing of the SAI valve has to be controlled in such a manner that it overcomes the above-mentioned problems associated with
25 mechanical secondary air injection.

[00015] Typically, electronically operated secondary air injection (E-SAI), which is controlled by a controller of the vehicle, ensures that the opening and closing of the SAI valve is controlled and secondary air injection is provided only during the cold phase until catalytic converter light off occurs, and SAI action does not take
30 place in other conditions.

[00016] Typically, E-SAI uses engine block temperature, coolant outlet temperature in case of liquid cooled engines, intake air temperature, exhaust gas temperature and catalytic converter temperature for controlling the opening and closing of the SAI valve. Further, E-SAI also determines the time taken from engine
5 start for computing the closing time of the SAI valve. Furthermore, E-SAI is also controlled by the controller based on air mass flow through the engine.

[00017] Even though E-SAI has been used in vehicles for quite some time now, there still exists certain drawbacks with the known E-SAI, which causes variation in time taken for catalytic converter light-off in cold phase of the engine.

10 [00018] Typically, in vehicles with higher capacity engines, for example, those operating at more than 200cc or engines with higher power output e.g. greater than 15 bhp, the temperature of exhaust gases exiting out of the exhaust port is on the higher side compared to vehicles with lesser capacity engines. Thus, in case of such higher capacity engines, the variation in time taken for catalytic converter light-off
15 is minimal. However, in case of vehicles with lesser capacity engines, the variation in time taken for catalytic converter light-off is predominant.

[00019] Additionally, in general IC engines demonstrating higher friction variation due to improper setting between the piston rings and the cylinder block or due to improper maintenance of the engine are more susceptible to such a variation in time
20 taken for catalytic converter light-off.

[00020] Further, the variation in the ratio of actual air-fuel ratio to the stoichiometric air-fuel ratio across different engines could potentially lead to variation in time taken for catalytic converter light-off. This is because any variation in the above ratio could result in the air-fuel mixture being supplied as too rich or
25 too lean, which may not be sufficient to induce oxidation of the exhaust gases.

[00021] There are also instances in which the variation in the functioning of the SAI valve causes a corresponding variation in the air-fuel mixture that is supplied at the exhaust passage. For instance, any deterioration in the SAI valve such as accumulation of dust particles or contamination of the SAI valve due to exhaust
30 gases back flow could make the SAI valve less responsive to the inputs received

from the controller, which typically causes deviation in the output of the SAI valve leading to the variation in the time taken for catalytic converter light-off.

[00022] In the case of vehicles with manual transmission, it is possible to increase the idling rpm and retard the ignition timing for causing an increase in the exhaust gas temperature. However, in case of vehicles with continuously variable transmission (CVT) and single speed transmission using centrifugal clutch, it is not possible to increase the idling rpm beyond a predetermined threshold as the vehicle tends to move. Therefore, in such vehicles using CVT and single speed transmission, the engine speed has to be limited for causing an increase in the exhaust gas temperature. This leads to undesirable variation in the time taken for catalytic converter light-off.

[00023] Further, any variation in ignition timing also causes a corresponding variation in the time taken for catalytic converter light-off.

[00024] Such a variation in time taken for catalytic converter light-off leads to inconsistent control of total hydrocarbon (THC) emission. This also affects the fuel efficiency of the engine as the combustion of THC is not effective. The variation in time taken for catalytic converter light-off further leads to increase in CO, NOx emissions in the exhaust gases.

[00025] Thus, there is a need to minimize the variation in time taken for catalytic converter light-off independent of engine capacity and the type of transmission of the vehicle.

[00026] In order to overcome the various problems associated with early catalytic converter light-off in case of different engines including engines with higher capacity, engines with lower capacity, engines using continuously variable transmission and single speed transmission, the present invention provides a controller that is capable of addressing the variation problem by designing an improved controller which is configured to operate by continuously detecting engine temperature, intake air temperature, coolant outlet temperature, exhaust gas temperature and catalytic converter temperature.

[00027] Further, the controller of the present invention, in an implementation, detects if the temperature values received from one or more temperature sensors are

greater than a predetermined threshold and activates an electronic secondary air injection valve of the present subject matter. The controller of the present invention, in an implementation, checks if the idling rpm is substantially closer to the desired idling rpm required for early light-off of the catalytic converter. In an embodiment, the idling rpm is increased and maintained at a range of 1700 rpm to 2300 rpm.

[00028] In case the controller detects that the idling rpm is substantially lesser or higher than the desired idling rpm of the engine that is required for early light-off of the catalytic converter, the controller, in an implementation, optimizes the opening of an idle air control valve (IACV) and/or the ignition timing of the engine, which results in achieving the desired idling rpm.

[00029] In an implementation, the controller detects if the ignition timing is maintained at a predetermined angle before the top dead centre (TDC). For instance, in an embodiment, the predetermined angle is in a range of -2 degrees to +2 degrees. In case the controller detects that the ignition timing is not maintained at a predetermined angle before the TDC, the controller, in an implementation, optimizes the opening of the IACV in order to achieve the desired ignition timing required for early light-off of the catalytic converter.

[00030] In case the engine is operated with an open loop, there is no precise control over an actual air-fuel ratio (λ) against a target stoichiometric air-fuel ratio, and this potentially results in a higher THC emission due to delay in light-off of the catalytic converter which is undesirable. On the contrary, when using a closed loop, it is possible to operate the engine closer to the stoichiometric air-fuel ratio, which leads to lower the THC emissions. However, when activating the electronic secondary air injection valve in case of such a closed loop, a potentially conflicting situation occurs, which leads to excessive load on the controller, as the secondary air injection valve continuously attempts to lean the air-fuel ratio against the functioning of the closed loop, which envisages maintaining the air-fuel ratio close to stoichiometric value. Hence, to overcome this problem, the controller of the present invention is enabled to shift the mean λ to leaner side while operating on

closed loop and when the electronic secondary air injection (E-SAI) valve is activated.

[00031] In an implementation, the target ratio (λ) at which the engine is being operated, is maintained in the range of 0.9 to 1.

5 [00032] Furthermore, the controller of the present invention checks if the temperature threshold is exceeding the predetermined value, and closes the E-SAI valve. In case the temperature threshold has not exceeded the predetermined temperature threshold value, the controller of the present invention, checks the time taken from the engine start, and closes the E-SAI valve, if the time taken from the engine start is equal to a predetermined value of time. In case, if both the
10 temperature threshold and the time taken has not exceeded beyond the respective predetermined threshold value, the controller calculates the mass air flow through the engine, and closes the E-SAI valve, if the mass air flow through the engine exceeds a predetermined threshold value.

15 [00033] The present invention achieves improved consistency in terms of time taken for light-off of the catalytic converter and eliminates variations occurred due to various engine parameters. More importantly, the present invention enables improved consistency across engine of various capacities and various types of transmissions, i.e., the present invention achieves consistency of catalytic converter light-off irrespective of the type of transmission being used and the capacity of the engine. This ensures that the total hydrocarbon emissions and other emissions including NO_x and CO are consistently reduced across different types of engines. Moreover, the present invention also ensures that the catalytic converter is not
20 damaged and the overall life of the catalytic converter is increased several times as the activation of the E-SAI valve is effectively controlled by the controller of the present invention.

[00034] The present invention enables optimization of noble metal loading in the catalytic converter as the time taken for light-off of the catalytic converter is consistent and reduced by the improved control of the E-SAI valve through the
30 controller of the present invention.

[00035] Moreover, the present invention ensures that the overall fuel efficiency of the engine is improved and consistently maintained due to better combustion resulting in reduced THC, NO_x and CO emissions.

5 [00036] The present invention can be advantageously applied to any internal combustion engine powered vehicle, which has a need to reduce the total hydrocarbon emissions.

[00037] To achieve the above said inventive features and technical advantages, the present subject matter comprises an exhaust control system. The exhaust control system comprises of an air filter communicatively connected to the engine, a catalytic converter communicatively connected to the engine, an air injecting valve
10 configured to receive inputs from the air filter, the air injecting valve is connected to an out path of the engine, and an controller configured to control the air injecting valve. The system also includes one or more sensors. The one or more sensors include an engine speed sensor, an intake air temperature sensor, an engine block
15 temperature sensor, an ignition timing sensor, a lambda sensor, an exhaust temperature sensor, and a catalyst temperature sensor.

[00038] The controller is configured to activate and de-activate the air injecting valve based on various inputs received from the one or more sensors.

[00039] The exhaust control system is operated under two conditions. The two
20 conditions include an open loop condition and a closed loop. The exhaust control system as per the present invention is configured to include one or more separate lambda controller maps. Whenever, the system is operated under open loop, the controller does not receive any feedback from the lambda sensor. On contrary, whenever the system is operated under closed loop, the feedback from the lambda
25 sensor is received by the controller.

[00040] Whenever the system is operated under closed loop condition, the controller is able to receive the feedback from the lambda sensor. Further, whenever one or more separate lambda controller maps feature is enabled, as in the present condition, the controller will not try to work to provide a rich mixture of air-fuel
30 ratio because separate lambda controller maps are being used. The E-SAI will continue to make the mixture lean.

[00041] Thus, during the cold phase start condition, it is important to supply the air-fuel mixture on the leaner side than the stoichiometric ratio, which is optimum for early light-off of the catalytic converter. However, it cannot be overly lean, which will lead to exhaust temperature reduction.

5 [00042] Therefore, using lambda controller maps along with E-SAI enables achieving faster light-off temperature by supplying optimum air-fuel mixture, which is lean and not overly lean, according to the present subject matter. The present subject matter is further described with reference to accompanying figures. It should be noted that the description and figures merely illustrate principles of the
10 present subject matter. Various arrangements may be devised that, although not explicitly described or shown herein, encompass the principles of the present subject matter. Moreover, all statements herein reciting principles, aspects, and examples of the present subject matter, as well as specific examples thereof, are intended to encompass equivalents thereof.

15 [00043] Figure 1 depicts a side view of an exemplary motor vehicle 100, in accordance with an embodiment of the present subject matter. The vehicle 100 has a frame assembly 105 (schematically shown with dotted lines) that includes a head tube 106, a main frame 107 extending rearwardly downward from the head tube 106. The main frame 107 may comprise one or more main tube(s), and a pair of
20 rear tubes 108 extending inclinedly rearward from a rear portion of the main tube. In the present embodiment, the vehicle 100 includes a step-through portion 109 defined by the frame member 105 of the vehicle 100. However, the aspects of the present subject matter are not limited to the depicted layout of the vehicle 100.

[00044] Further, a handlebar assembly 110 is connected to a front wheel 115
25 through one or more front suspension(s) 120. A steering shaft (not shown) connects the handlebar assembly 110 to the front suspension(s) 120 and the steering shaft is rotatably journaled about the head tube 106. An internal combustion (IC) 201 is mounted to the frame member 105. The engine 201 may also include a traction motor either hub mounted or mounted adjacent to the IC engine. In the depicted
30 embodiment, the engine 201 is disposed below at least a portion of the rear frame(s) 108. However, in an alternative embodiment, the power unit may be fixedly

disposed towards front and below the main tube 107. The engine 201 is functionally connected to a rear wheel 130 through a transmission system (not shown). The vehicle may include one or more rear wheel(s). The transmission system includes any one of a continuously variable transmission (CVT), a fixed gear ratio
5 transmission, or automatic-manual transmission (AMT) controlled by an AMT control unit. Further, the vehicle 100 includes an air induction system (not shown) that provides air to an air-fuel mixing unit (not shown). A fuel tank (not shown) stores and supplies fuel to the air-fuel mixing unit, wherein the air-fuel mixing unit can be a carburetor or a throttle body with fuel injector. Also, the vehicle 100
10 includes an exhaust system 200 that helps in dissipation of exhaust gasses from the IC engine. The exhaust system 200 includes a muffler 135 mounted to the vehicle 100. In the depicted embodiment, the muffler 135 is disposed towards one lateral side of the vehicle 100.

[00045] Further, the rear wheel 130 is connected to the frame member 105
15 through one or more rear suspension(s) (not shown). In the depicted embodiment, the engine 201 is swingably mounted to the frame member 105 through a toggle link 150 or the like. A seat assembly 140 is supported by the frame member 105 and is disposed rearward to the step-through portion 109.

[00046] Further, the vehicle 100 includes a front fender 155 covering at least a
20 portion of the front wheel 115. In the present embodiment, a floorboard 145 is disposed at a step-through portion 109 and is supported by the main frame 107 and a pair of floor frames (not shown). The user can operate the vehicle 100 by resting feet on the floorboard 145, in a sitting position. In an embodiment, a fuel tank (not shown) is disposed below the seat assembly 140 and behind the utility box. A rear
25 fender 160 is covering at least a portion of the rear wheel 135. The vehicle 100 comprises of plurality of electrical/electronic components including a headlight 165, a tail light (not shown), a battery (not shown), a transistor-controlled ignition (TCI) unit (not shown), an alternator (not shown), a starter motor (not shown). Further, the vehicle 100 may include a synchronous braking system, an anti-lock
30 braking system.

[00047] The vehicle 100 comprises plurality of panels that include a front panel 170 disposed in an anterior portion of the head tube 106, a leg-shield 171 disposed in a posterior portion of the head tube 106. A rear panel assembly 172 includes a right-side panel and a left side panel disposed below the seat assembly 140 and extending rearward from a rear portion of the floorboard 145 towards a rear portion of the vehicle 100. The rear panel assembly 172 encloses a utility box disposed below the seat assembly 140. Also, the rear panel assembly 172 partially encloses the engine 201. Also, the muffler 135 of the exhaust system is coupled to exhaust side of the IC engine and in an implementation the muffler 135 is disposed towards one lateral side of the vehicle 100.

[00048] Figure 2 illustrates a block diagram of an exhaust control system according to an embodiment of the present invention. The exhaust control system 300 includes an air filter 202 communicatively connected to the engine 201. A treatment device 203 is communicatively connected to the engine 201. An air injecting valve 204 is configured to receive inputs from said air filter 202, wherein, the air injecting valve 204 is communicatively connected to an out path of the engine 201. All the above said components are connected to a controller 205. The controller is configured to control said air injecting valve 204.

[00049] The functionality of the controller is based on the inputs received from the one or more sensors (206, 207, 208, 209, 210, 211, and 212) including Intake air temperature sensor 206, Engine block temperature sensor 207, Exhaust temperature sensor 208, catalyst temperature sensor 209, an engine speed sensor 210, an ignition timing sensor 211, and a lambda sensor 212.

[00050] The functionality of the controller 205 is provided in the below description of methods performed by the controller 205.

[00051] In an embodiment, the controller 205 is configured to activate the air injecting valve 204 at least based on the one or more operating parameters detected by the one or more sensors 206, 207, 208, 209, 210, 211. The controller will activate the air injecting valve only when the operating parameters being lower than a first pre-determined threshold condition.

[00052] Further, according to the present embodiment, the controller 205 is configured to de-activate the air injecting valve 204 at least based on an activation of a lambda sensor 212.

5 [00053] Further, the controller 205 is also configured to de-activate the air injecting valve 204 at least based on one or more second engine parameters 309-1, 309-2 (not shown), 309-3 being equal to a third pre-determined condition.

[00054] According to another embodiment of the present invention, the controller 205 is configured to activate the air injecting valve 204, at least based on one or more operating parameters detected by said one or more sensors (206, 207, 208, 10 209, 210, 211) and feedback received from the lambda sensor (212) by simultaneously activating a lambda controller maps (205a) configured in the controller (205),

[00055] The one or more operating parameters here are lower than a first pre-determined threshold condition.

15 [00056] Figure 3 illustrates a first embodiment of the present invention, wherein the exhaust control system is controlled by a first method as provided below.

[00057] The method for the exhaust control system comprises the following steps:

[00058] Firstly, at step 301, the controller starts the method including the various steps as provided below.

20 [00059] Detecting continuously and receiving one or more plurality of operating parameters of the engine by one or more sensors 206, 207, 208, 209, 210, 211 as indicated in step 302.

[00060] Further, in step 303, checking if the one or more operating parameters are lower than a first pre- determined threshold condition during activation of the 25 engine 201.

[00061] Activating an air injection valve 204, if the one or more operating parameters are lower than the first pre-determined threshold condition as indicated in step 304.

[00062] Monitoring one or more first engine parameters and comparing at step 305-1, 305-2 if said one or more first engine parameters are equal to a second pre-determined condition as indicted in step 305-1, 305-2.

5 [00063] Optimizing an Idle air control valve as indicated in step 306 to optimize the one or more first engine parameters to be equal to said second pre-determined condition.

[00064] Checking if a lambda sensor 212 is enabled as indicated in step 307.

[00065] If so, then the air injection valve 204 is de-activated and the lambda sensor 212 is enabled.

10 [00066] If no, then monitoring continuously at steps 309-1, 309-2, 309-3 one or more second engine parameters, if said lambda sensor 212 is not enabled; and

[00067] De-activating at step 310 said air injecting valve 204 if said one or more second engine parameters are equal to a third pre-determined condition.

15 [00068] Figure 4 illustrates a method to control an exhaust system according to a second embodiment.

[00069] The method comprises the steps of detecting continuously and receiving at step 402 one or more operating parameters of said engine by one or more sensors 206, 207, 208, 209, 210, 211, and 212.

20 [00070] comparing at step 403 if the one or more operating parameters are lower than a first pre-determined threshold value during activation of said engine.

[00071] If so, then activating at step 404 an air injection valve 204 and if not then not activating the valve and allowing normal operation.

[00072] Pose activation of valve at step 404, comparing at steps 405-1, 405-2 if one or more first engine parameters are equal to a second pre-determined condition.

25 [00073] Optimizing at step 406 an Idle air control valve to optimize said one or more first engine parameters to be equal to said second pre-determined condition.

[00074] Checking continuously at step 407, if a lambda sensor 212 is enabled.

[00075] Activating at step 408 one or more separate lambda controller maps 205a for said air injecting valve 204 if said lambda sensor 212 is enabled.

[00076] Monitoring continuously at step 309-1, 309-2, 309-3, if one or more second engine parameters and below threshold limit, and

5 [00077] De-activating at step 410 the air injecting valve 204 if said one or more second engine parameters are equal to a third pre-determined condition.

[00078] According to the present embodiment, the one or more first engine parameters include idling engine speed 210, ignition timing 211.

10 [00079] The one or more operating parameters include engine block temperature, intake air temperature, coolant outlet temperature, exhaust temperature, catalyst temperature, oxygen, and altitude.

[00080] The one or more second engine parameters (309-1, 309-2, 309-3), in the present embodiment, include temperature 309-1, time after engine start 309-2, and air mass flow of engine 309-3.

15 [00081] The separate lambda controller maps as provided in the present embodiment enables to operate the Lambda value in closed loop at values of more than 1, for example, 1.05 to 1.15. The significance of operating lambda with a value of more than one includes, the controller 205 will not try to maintain the air-fuel mixture to richer side because of the presence of the separate lambda controller maps. The air injecting valve will continue to make the air-fuel mixture lean
20 irrespective of all variations outlined earlier thereby enabling a robust exhaust control system.

[00082] Further, during cold phase start condition, the exhaust temperature would not have reached sufficiently high enough for CAT Light-off. Thus, in this case, it
25 is important to supply the air-fuel mixture on the leaner side than the stoichiometric ratio. However, it cannot be overly lean, which will lead to exhaust temperature reduction.

[00083] Therefore, using lambda sensor along with activation of the air injecting valve enables achieving faster light-off temperature by supplying optimum air-fuel

mixture, which is lean and not leaner. Further, due to the separate lambda controller, the overload on the controller is eliminated.

[00084] Figure 5 shows a conventional characteristic curve depicting the THC emission traces of a typical vehicle in case of a World motorcycle test cycle (WMTC) without the use of an electronic secondary air injection (E-SAI) valve. The graphical representation as provided in the Figure 5 illustrates two curves. The THC emission X and the cumulative THC representation Y. Typically, the WMTC cycle consists of two phases: first phase (first 600 seconds) and second phase (600 – 1199 seconds). First phase emission is most critical and it can be seen that almost 65% of the total THC is emitted in first 200 seconds. Thus, the conventional characteristic curve as depicted in Fig. 5 clearly indicates the need for controlling the emissions in the first phase. Therefore, the present invention is aimed at reducing the emissions in the first phase. In view of reducing the emissions in the first phase, the present invention provides a controller and a method of controlling an air injecting valve by means of the controller. As can be seen in Fig. 5, the cumulative emission (%) in the first phase is almost 80% of the total THC emissions, while the second phase contributes to the remaining 20% of the total THC emissions.

[00085] Figure 6 shows the cumulative effect of activating E-SAI valve, maintaining desired idling rpm, target ignition timing and activation of lambda sensor. In the comparative study, the engine speed at different values is indicated by ES1 and ES2. The first engine speed ES1 is lower than the second engine speed ES2. The different engine speeds ES1 and ES2 are considered for comparative study of the exhaust temperatures at different locations and with/without activation of air injecting valve as explained below.

[00086] The curve that indicates the exhaust gas temperature, a first temperature 11-A and 11-B, for example, the exhaust gas temperature detected proximal to the exhaust port, and a curve indicating the second temperature 12-A and 12-B, for example, the before catalyst temperature, detected distal to the exhaust port than the first temperature 11-A and 11-B. It has been observed that the first temperature

with activation of SAI 11-B is increased by approximately 70°C to 90°C, and second temperature with activation of SAI is increased by approximately 100°C to 110°C within first 20 seconds of the WMTC cycle. This enables in achieving faster catalytic converter light-off thereby reducing cold phase THC emission.

- 5 [00087] Figure 7 shows the comparison between base THC emission and E-SAI optimized THC emission. It can be inferred that after optimizing E-SAI based on the various parameters mentioned in the preceding paragraphs, the cumulative THC emission 512 is reduced by approximately 10% to 20% in the first 200 seconds FF as compared to the conventional cumulative THC representation Y. Thus, the
10 overall THC emission is reduced in the first phase itself, which further has an effect on the overall reduction of other emissions such as NOx and CO.

- [00088] It is to be understood that the aspects of the embodiments are not necessarily limited to the features described herein. Many modifications and variations of the present subject matter are possible in the light of above disclosure.
15 Therefore, within the scope of claims of the present subject matter, the present disclosure may be practiced other than as specifically described.

List of reference signs

	100	vehicle
	105	frame member
	106	head tube
5	107	main frame
	108	rear frame
	109	step-through space
	110	handlebar assembly
	115	front wheel
10	120	front suspension
	125	power unit
	130	rear wheel
	135	muffler
	140	seat assembly
15	145	floorboard
	150	toggle link
	155	front fender
	160	rear fender
	165	headlight
20	170	front panel
	171	leg shield
	172	rear panel assembly
	180	cylinder block
	181	crankcase
25	182	toggle link
	200	exhaust system
	201	internal combustion engine
	202	air filter
	203	treatment device

- 204 air injection valve
- 205 electronic control valve
- 206, 207, 208, 209, 210, 211, 212 one or more sensors
- 210 engine speed
- 5 211 ignition timing
- 212 lambda sensor
- 205 controller
- 205a lambda controller lamps
- X THC emission
- 10 Y cumulative THC representation
- ES1 first engine speed
- ES2 Second engine speed
- 11-A and 11-B first temperature
- 12-A and 12-B second temperature
- 15 512 cumulative THC emission

We claim:

1. An exhaust control system for an internal combustion engine of a vehicle, said exhaust control system comprising:
 - 5 an air filter (202) communicatively connected to said engine (201);
 - a treatment device (203) communicatively connected to said engine (201);
 - an air injecting valve (204) configured to receive inputs from said air filter (202), said air injecting valve (204) communicatively connected to an out
 - 10 path of said engine (201);
 - one or more sensors (206, 207, 208, 209, 210, 211) configured to detect one or more operating parameters; and
 - a controller (205) configured to control said air injecting valve (204),
 - said controller (205) is configured to activate said air injecting
 - 15 valve (204), at least based on said one or more operating parameters detected by said one or more sensors (206, 207, 208, 209, 210, 211), wherein the activation of said air injecting valve is based on said one or more operating parameters being lower than a first pre-determined threshold condition.
- 20 2. An exhaust control system for an internal combustion engine of a vehicle, said exhaust control system comprising:
 - an air filter (202) communicatively connected to said engine (201);
 - a treatment device (203) communicatively connected to said engine
 - 25 (201);

an air injecting valve (204) configured to receive inputs from said air filter (202), said air injecting valve (204) connected to an out path of said engine (201);

5 one or more sensors (206, 207, 208, 209, 210, 211, and 212) configured to detect one or more operating parameters; and
a controller (205) configured to control said air injecting valve (204),

10 said controller (205) is configured to activate said air injecting valve (204), at least based on one or more operating parameters detected by said one or more sensors (206, 207, 208, 209, 210, 211, and 212) and feedback received from said lambda sensor (212) by simultaneously activating a lambda controller maps (205a) configured in said controller (205), and wherein said one or more operating parameters being lower than a first pre-determined threshold condition.

15 3. A method for an exhaust control system (300) of an internal combustion engine (201) of a vehicle (100), said method comprising the steps of:

receiving (302) one or more operating parameters of said engine from one or more sensors (206, 207, 208, 209, 210, 211), by a controller (205);

20 comparing (303) if said one or more operating parameters are lower than a first pre-determined threshold condition during activation of said engine (201);

activating (304) an air injection valve (204), if said one or more operating parameters are lower than said first pre-determined threshold condition;

25 comparing (305-1, 305-2) if one or more first engine parameters are equal to a second pre-determined condition;

checking (307) if a lambda sensor (212) is enabled; and

de-activating (210) said air injection valve (204) if said lambda sensor (212) is enabled.

4. A method for an exhaust control system (300) of an internal combustion engine (201) of a vehicle (100), said method comprising the steps of:

5 receiving (402) one or more operating parameters of said engine by one or more sensors (206, 207, 208, 209, 210, 211, and 212);

comparing (403) if said one or more operating parameters are lower than a first pre-determined threshold condition during activation of said engine;

10 activating (404) an air injection valve (204), if said one or more operating parameters are lower than said first pre-determined threshold condition;

comparing (405-1, 405-2) if said one or more first engine parameters are equal to a second pre-determined condition;

15 checking continuously (407) if a lambda sensor (212) is enabled;

activating (408) a separate lambda controller maps (205a) if said lambda sensor (212) is enabled;

monitoring continuously (309-1, 309-2, 309-3) one or more second engine parameters; and

20 de-activating (410) said air injecting valve (204) if said one or more second engine parameters (309-1, 309-2, 309-3) are equal to a third pre-determined condition.

5. The exhaust control system for an internal combustion engine of a vehicle as claimed in claim 1, wherein said one or more operating parameters include
25 engine block temperature, intake air temperature, coolant outlet temperature, exhaust temperature, catalyst temperature, and altitude.

6. The exhaust control system for an internal combustion engine of a vehicle as claimed in claim 1, wherein said controller (205) is configured to de-activate said air injecting valve (204), at least based on an activation of a lambda sensor (212).
- 5 7. An exhaust control system for an internal combustion engine of a vehicle as claimed in claim 1, wherein said controller (205) is configured to de-activate said air injecting valve (204) at least based on one or more second engine parameters (309-1, 309-2, 309-3) being equal to a third pre-determined condition.
- 10 8. The exhaust control system for an internal combustion engine of a vehicle as claimed in claim 1, wherein said operating parameters include engine block temperature, intake air temperature, coolant outlet temperature, exhaust temperature, catalyst temperature, and altitude.
- 15 9. The exhaust control system for an internal combustion engine of a vehicle as claimed in claim 1, 2,3, or 4, wherein said one or more sensors (206, 207, 208, 209, 210, 211) include an intake air temperature sensor (206), an engine block temperature sensor (207), an exhaust temperature sensor (208), a catalyst temperature sensor (209), an engine speed sensor (210), and an ignition timing sensor (211).
- 20 10. The exhaust control system for an internal combustion engine of a vehicle as claimed in claim 2, wherein said controller (205) is configured to de-activate said air injecting valve (204) at least based on one or more second engine parameters (309-1, 309-2, 309-3) being equal to a third pre-determined condition.
- 25 11. The exhaust control system for an internal combustion engine of a vehicle as claimed in claim 1, 2, 3 or 4 wherein said operating parameters include engine

block temperature, intake air temperature, coolant outlet temperature, exhaust temperature, catalyst temperature, altitude, and oxygen.

12. The method for an exhaust control system (300) of an internal combustion engine (201) of a vehicle (100) as claimed in claim 1,3 or 4, wherein said one
5 or more sensors (206, 207, 208, 209, 210, 211, 212) include an Intake air temperature sensor (206), an engine block temperature sensor (207), an exhaust temperature sensor (208), a catalyst temperature sensor (209), an engine speed sensor (210), an ignition timing sensor (211), and a lambda sensor (212).

13. The method for an exhaust control system (300) of an internal combustion
10 engine (201) of a vehicle (100) as claimed in claim 3, wherein said method comprising the steps of:

monitoring continuously (309-1, 309-2, 309-3) one or more second engine parameters, if said lambda sensor (212) is not enabled; and

de-activating (310) said air injecting valve (204) if said one or more
15 second engine parameters are equal to a third pre-determined condition.

14. The method for an exhaust control system (300) of an internal combustion engine (201) of a vehicle (100) as claimed in claim 3, wherein said method comprises the step of:

optimizing (306) an Idle air control valve to optimize said one or more
20 first engine parameters to be equal to said second pre-determined condition.

15. The method for an exhaust control system (300) of an internal combustion engine (201) of a vehicle (100) as claimed in claim 3, wherein said method comprising the step of:

optimizing (406) an Idle air control valve to optimize said one or more
25 first engine parameters to be equal to said second pre-determined condition.

16. The method for an exhaust control system (300) of an internal combustion engine (201) of a vehicle (100) as claimed in claim 4, wherein said air injecting valve (204) is not activated (311) if said one or more operating parameters are lower than a first pre-determined threshold condition during activation of said engine.
17. The exhaust control system for an internal combustion engine of a vehicle as claimed in claim 4, wherein said one or more second engine parameters (309-1, 309-2, 309-3) include temperature (309-1), time after engine start (309-2), air mass flow of engine (309-3).
18. The method for an exhaust control system (300) of an internal combustion engine (201) of a vehicle (100) as claimed in claim 4, wherein said one or more first engine parameters include an idling engine speed (210), and an ignition timing (211).
19. The method for an exhaust control system (200) of an internal combustion engine (201) of a vehicle (100) as claimed in claim 19, wherein said idling engine speed (210) is in the range of 1700 rpm to 2300 rpm.

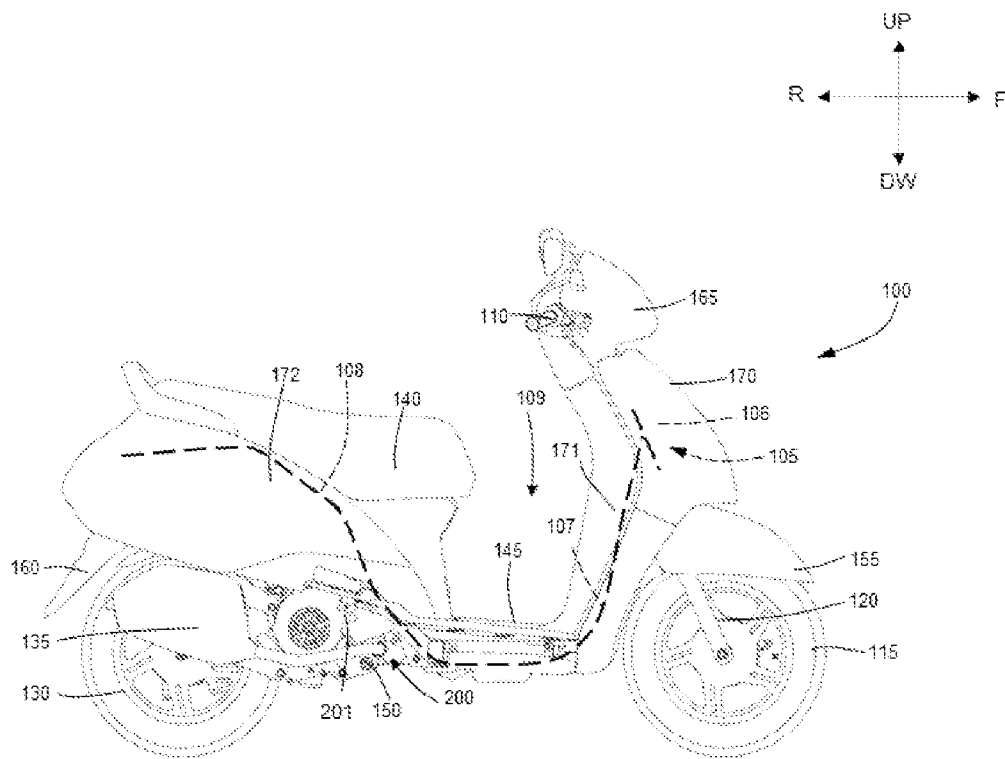


Figure 1

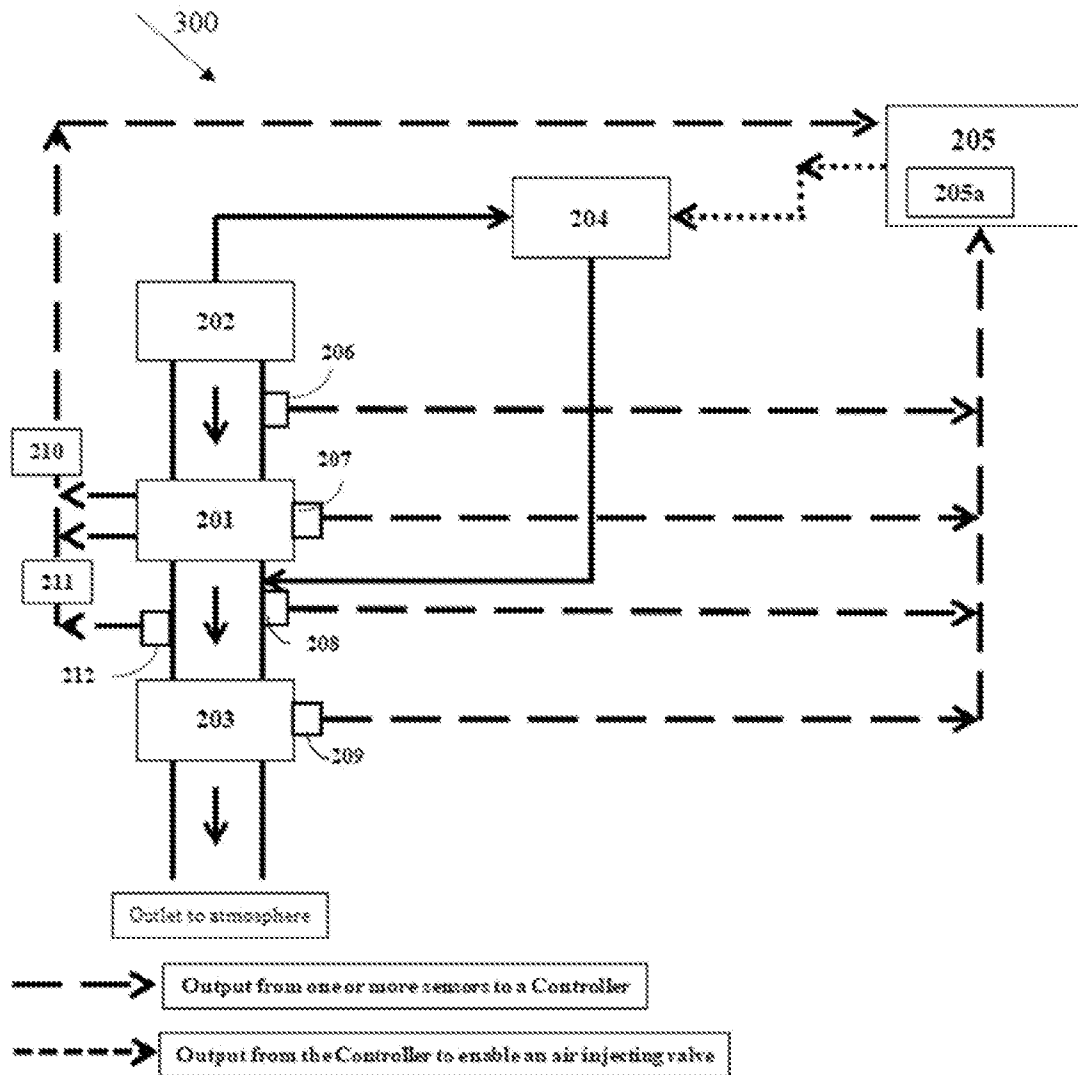


Figure 2

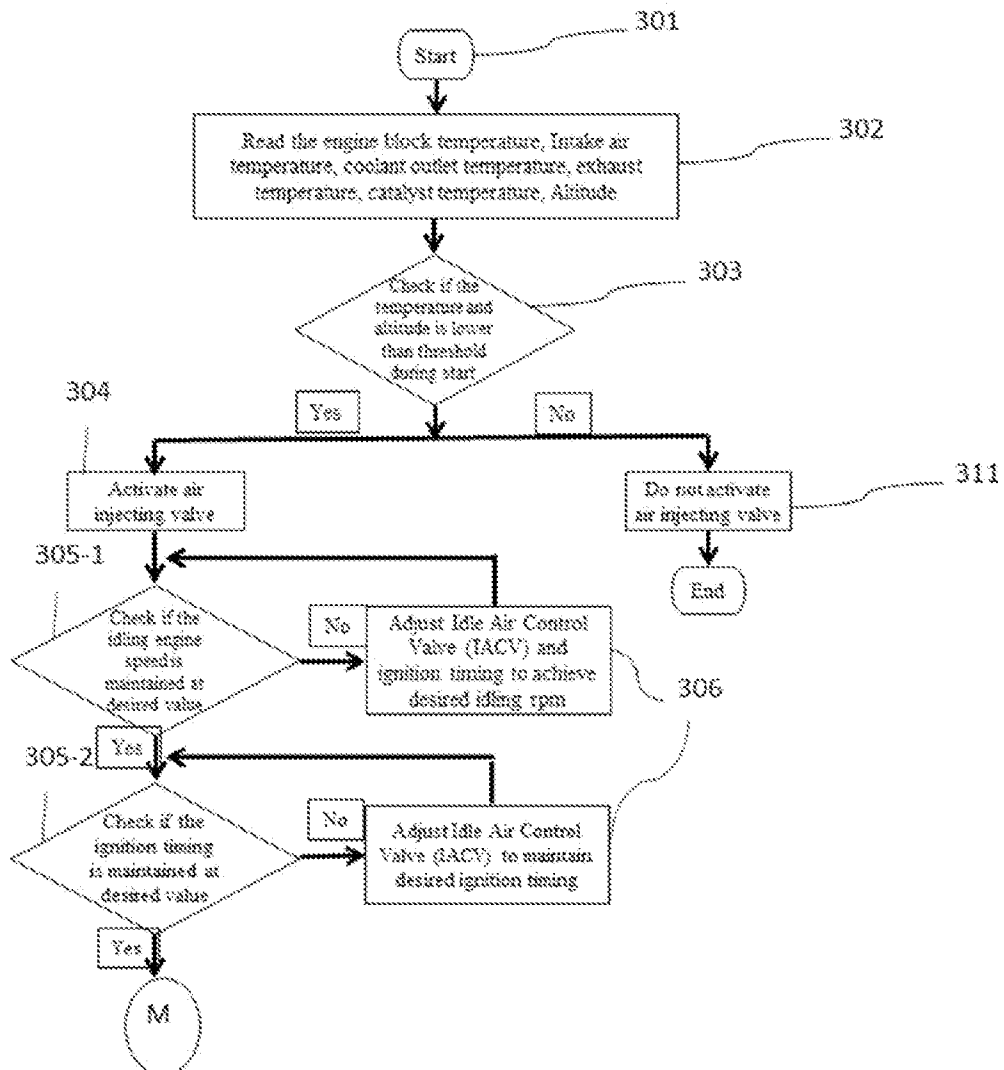


Figure 3

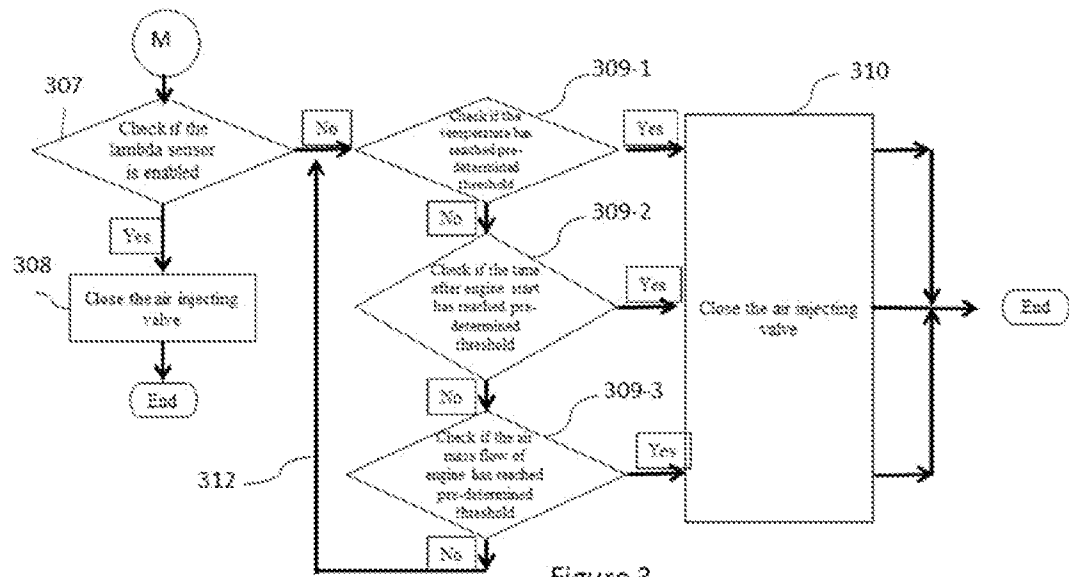


Figure 3

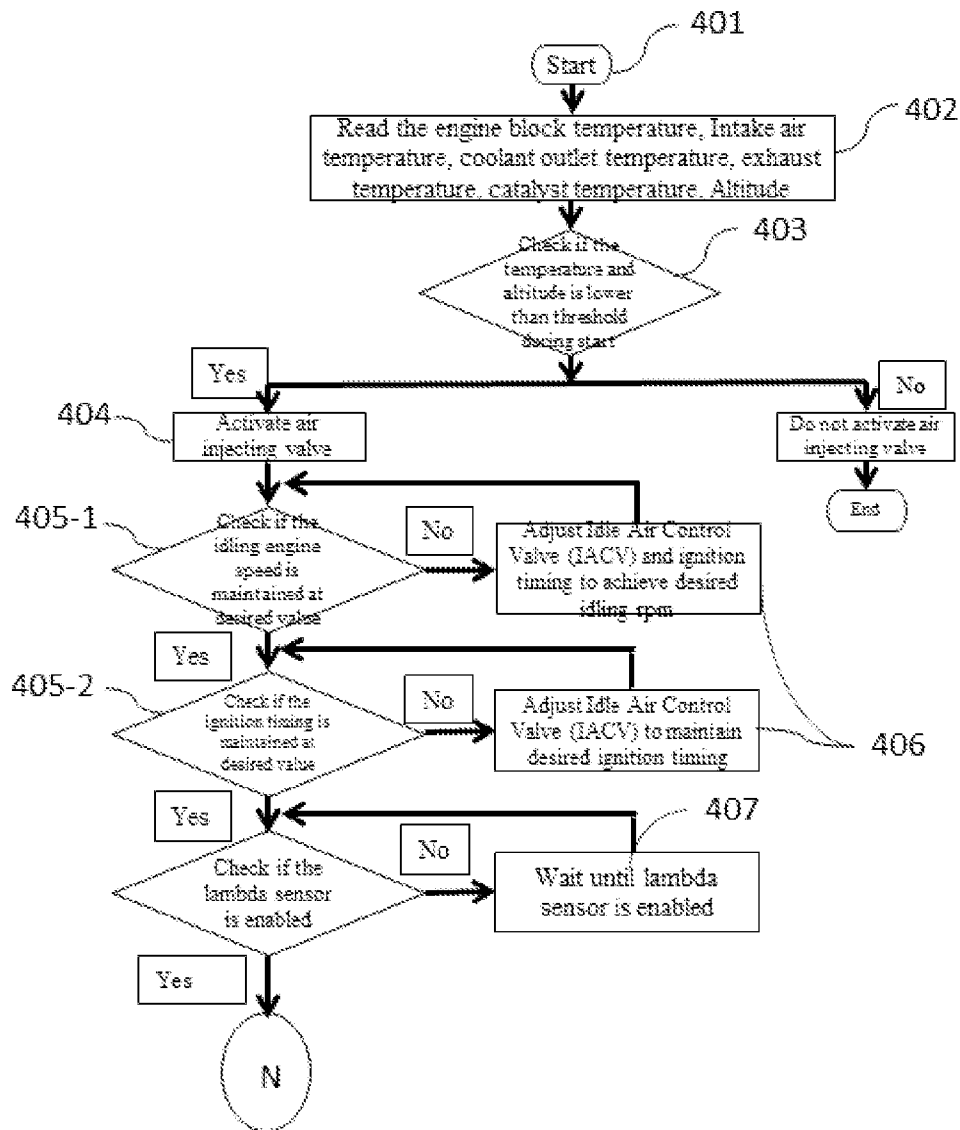


Figure 4

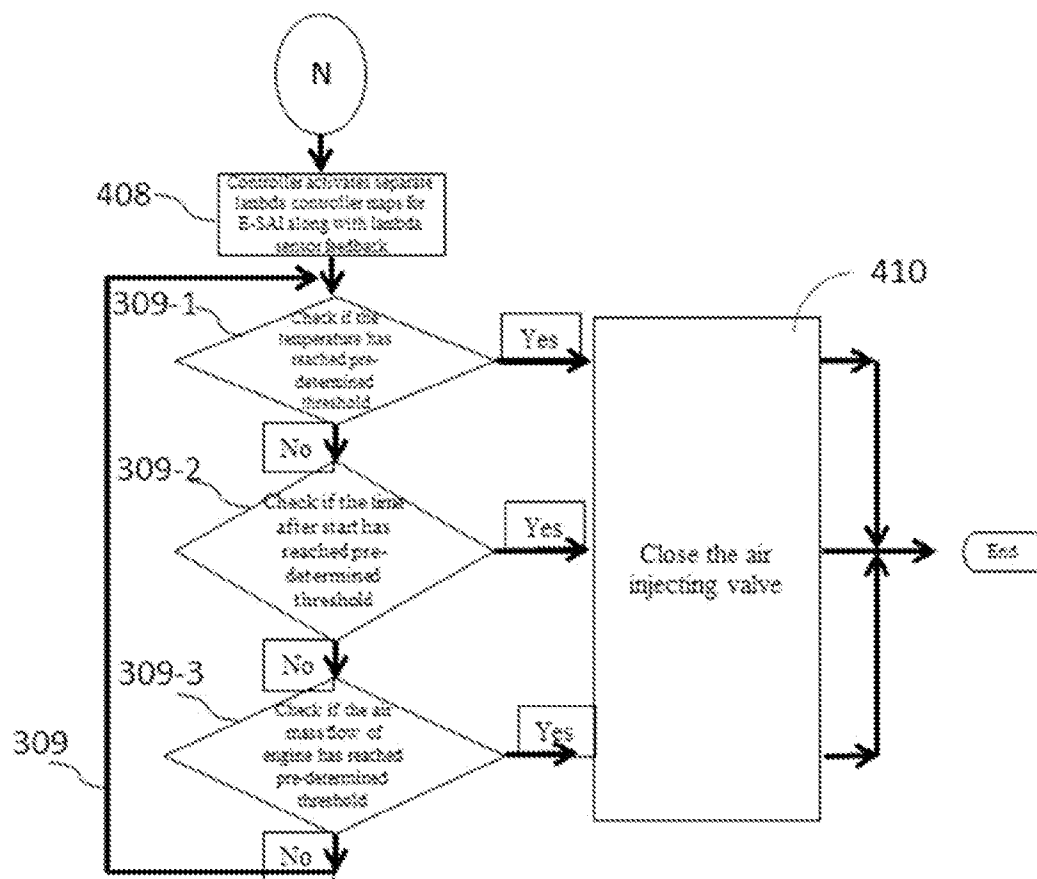


Figure 4

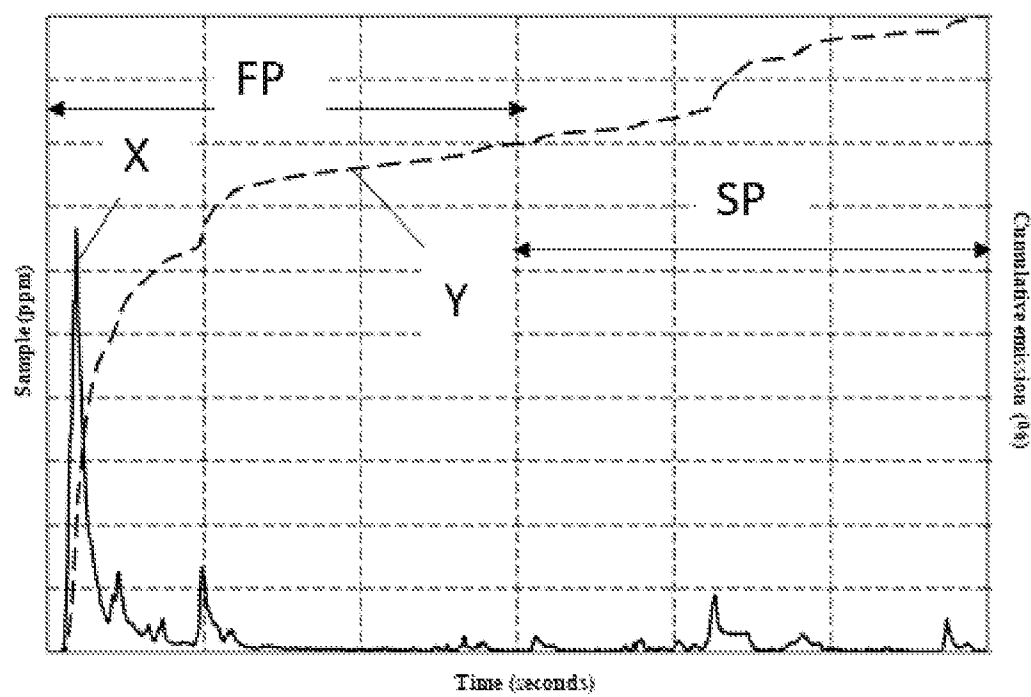


Figure 5

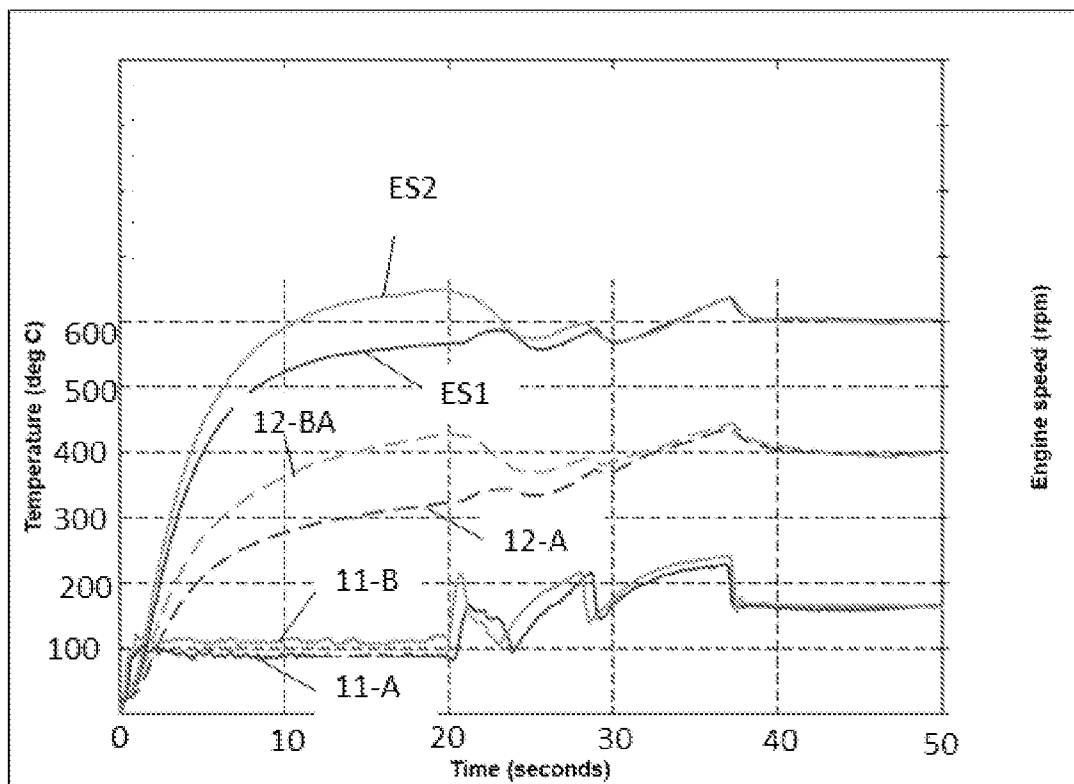


Figure 6

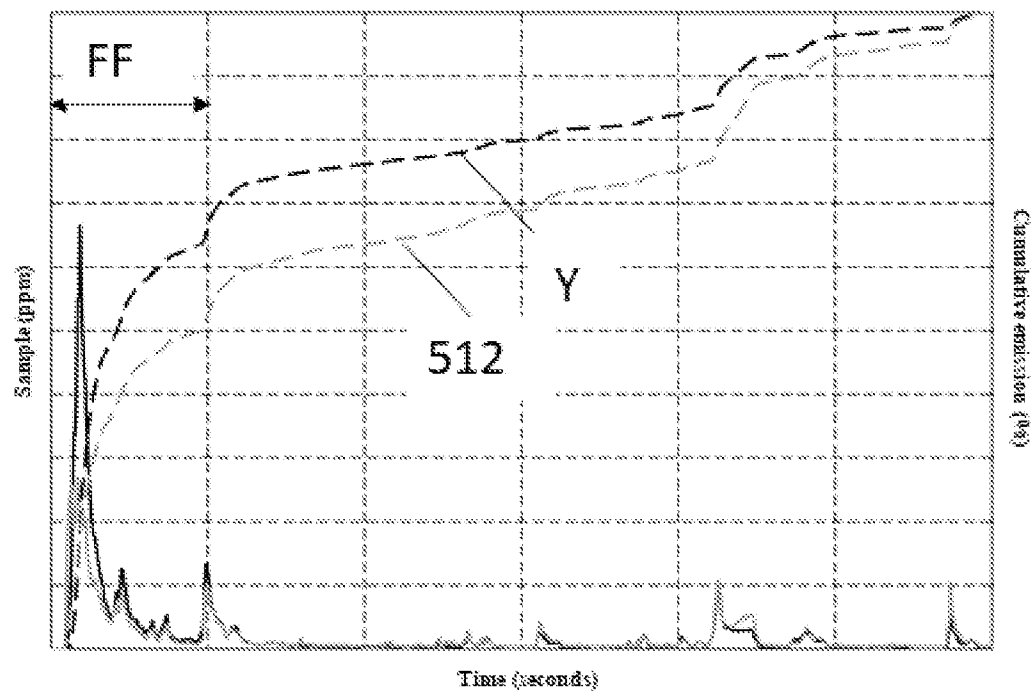


Figure 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2021/050665

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01N3/22
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01N F02D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 450 680 A (OTSUKA KAZUO [JP] ET AL) 29 May 1984 (1984-05-29) column 3, line 49 - column 5, line 13 column 6, line 49 - column 11, line 14 -----	1-19
X	WO 2014/196122 A1 (TOYOTA MOTOR CO LTD [JP]) 11 December 2014 (2014-12-11) abstract; figures 1,4,7 paragraphs [0031] - [0034], [0037] -----	1,5,8,9, 11,12,19
X	US 2019/271251 A1 (UKROPEC ROBERT [DE] ET AL) 5 September 2019 (2019-09-05) abstract; figure 7 -----	1,5,8,9, 11,12,19
X	US 2013/312391 A1 (CAVATAIO GIOVANNI [US] ET AL) 28 November 2013 (2013-11-28) abstract; figures 1-5 -----	1,5,8,9, 11,12,19



Further documents are listed in the continuation of Box C.



See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search

5 November 2021

Date of mailing of the international search report

18/11/2021

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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