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(54) **Title:** EMISSION CONTROL SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

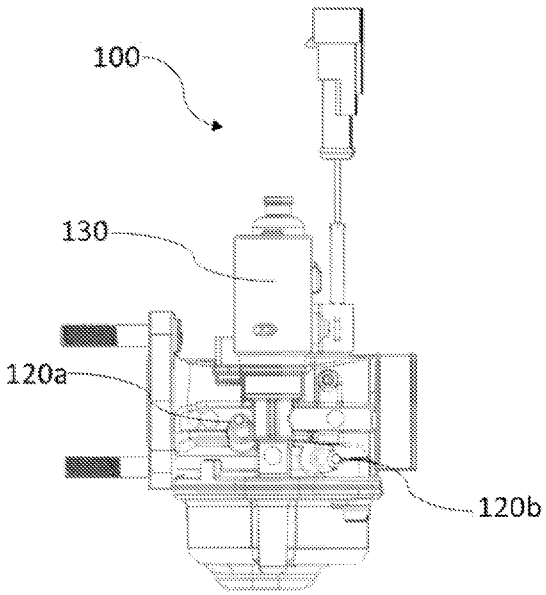

Figure 1

(57) Abstract: The present invention relates to an emission control method and system configured to have an intelligent carburetor system (100) in order to achieve functionality of precise air-fuel mixture control in engine cold start and idle condition in a conventional carburetor at low cost, achieve early light-off characteristics of catalyst by exhaust gas heating and along with precise air-fuel mixture control thereby increasing its conversion efficiency to reduce cold phase emissions significantly. Said intelligent carburetor system (100) has a carburetor with a pilot circuit (105), a main circuit (110) and a manual starter circuit (115), one or more dedicated air-bleed paths (120a, 120b), one or more actuators (125a, 125b) for said pilot circuit (105) and said main circuit (115), a proportional/linear actuator (130) for said manual starter circuit (115) to deliver instantaneous target value of air-fuel mixture and an engine controller for monitoring one or more sensors to control ignition timing.

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EMISSION CONTROL SYSTEM FOR AN INTERNAL COMBUSTION ENGINE

FIELD OF INVENTION

[0001] The present subject matter relates generally to an emission control device. More particularly but not exclusively, the present invention relates to an emission control system for an internal combustion engine.

BACKGROUND OF INVENTION

[0002] Generally, in a vehicle, the emissions generated during engine cold-start and idle conditions play a major role in total emission for compliance to strict regulations. So, reducing emissions in that zone/state is of primordial importance. In order to address the concern, manufactures adopt multiple strategies to control emissions during cold idling such as a) Idle air by-pass and injection quantity control for charge mixture control, b) Ignition timing and engine speed control for fast catalyst heating by increasing exhaust gas temperature.

[0003] In a carburetted engine, realizing strategy (b) is generally an extension to engine control already available and can be achieved by software development at no extra cost. But strategy (a) requires an additional by-pass path and actuator such as stepper motor for air quantity control, and another actuator such as injector, fuel pump for fuel quantity control and a housing such as throttle body to accommodate both, all at an extra packaging space, additional number of complex components and extra cost. Even though the charge mixture control is achieved better compared to a conventional carburettor system, the cost penalty to be paid is substantially high.

[0004] Conventionally vehicles are designed with a carburettor system to achieve a target air-fuel ratio which is ideally intended to be maintained at stoichiometric ratio with a value of Lambda = 1. Most carburetors are designed to work with a manual choke system. Such known arts have considerable limitations in the ability to maintain good Air-

Fuel ratio (AF) throughout the various load duty cycle of usage of the vehicle as well as the various operating range of an IC engine. The operating condition of the engine can be split into two prime regions for simplicity i.e. first is the cold start or idling region and second is the high-speed region beyond the warm up limit.

[0005] While conventional carburettor systems were capable of being tuned and calibrated to deliver optimum AF charge during the second region, there lied a challenge of it being not capable of delivering optimum charge in the first region at the same time. Thus the engineer had no choice but to calibrate the carburettor for the second region which is done in form a primary or main circuit and a pilot circuit for flow of the AF mixture. The primary circuit has an adjustment mechanism for the user to open or close a fixed amount of opening for the charge to pass through which is typically referred to as the idle setting mechanism. It is to be noted that maximum contribution to the emissions from an engine i.e. more than 70% of the contribution tends to come from the first region of usage or operation of the engine. Thus, it became imperative to address the first region to reduce emissions. Additionally, in the first region the challenge of cold start often leads to poor startability of a vehicle with the user ending up trying to kick start the vehicle multiple times which is undesirable. This problem becomes severe especially when the vehicle needs to be used in cold climates including sub-zero temperatures. Manual or electric cranking at cold condition of the engine lead to user dissatisfaction as well as discomfort. A preliminary solution in form of a choke circuit or a starter circuit is typically incorporated which enables a rich charge to be supplied to the intake port to ensure quick start from a cold condition albeit at a great disadvantage and compromise on further increase in emissions. Further advancements of such starter circuit system have resulted in an auto-choke system working on a two stage solenoid mechanism which has basically eliminated the need for the user to manually engage the choke to start during cold environmental conditions. However such solutions ended up either giving no improvement during cold start conditions or worsening the emissions during idling owing to the compromise.

[0006] Above challenges led to development of an EFI technology wherein the air and fuel inputs are enabled to have separate or independent control to achieve a precise air-fuel ratio which is precisely controlled by an ECU in the form of a closed loop control system. Unlike an EFI system a carburettor system has a major drawback of not being able to independently control the magnitude of air and fuel being supplied to the combustion chamber to achieve target AF ratio delivered for each instantaneous moment of operation of the engine. EFI systems known in the art are configured to work or operate with a stepper motor or two stage on-off solenoid system or a PWM (Pulse Width Modulation) solenoid system to control the amount of air being supplied to the intake port of an engine. Owing to the enhanced control on the AF mixture, the effectiveness of combustion of the charge inside the combustion chamber is greatly enhanced and thereby it leads to a significant reduction in emissions in form on unburnt fuel, etc.

[0007] Thus, EFI systems have enabled a higher magnitude of reduction in the emissions while also enhancing the efficiency of the engine by enabling better combustion of the charge. Since emissions are not completed eliminated in form of NOx and HC, typically a catalyst is incorporated downstream of the exhaust port to address the emissions further before being released to the atmosphere. It is known in the art that similar to the requirement for an engine to reach warm up temperature or optimum temperature to work efficiently, a catalyst also needs to reach its light off temperature to work effectively. Thus, it has been a challenge for typical low cost compact vehicle designs to achieve earliest possible light off of the catalyst to achieve lowest possible emissions. As per known arts, a separate heater has been employed to pre-heat the catalyst to quickly reach the light off temperature which albeit is at a trade-off on the overall energy efficiency of the power unit since the energy required to heat is again to be drawn from the IC engine itself.

[0008] As an alternate solution, in case of an EFI, known art has implemented an ECU based spark timing control feature in form of a time advance / retard functionality which delays the combustion to enable early light off of the catalyst. The combustion tends to occur when the charge is about to exit the exhaust port or sometimes even later near to the catalyst which ends up pushing the higher temperature gases closer to the catalyst thereby heating up the catalyst faster. Such ignition advance / retard functionality is relatively feasible to implement in an EFI system since it can be controlled by a closed loop ECU feedback control system which can monitor the temperature of the catalyst and enable calibration or programming of the ECU to command the advance / retardation of the spark timing for each instantaneous moment to get lowest emission results. The ECU for the EFI can also perform the dual function of spark timing control. However, the primary challenge of above is the need to have a dedicated fuel injector system which is a significantly high cost technology for a low-cost compact vehicle. The cost of such technology in proportion to the cost of the low-cost compact vehicle can become unviable and thus is not always a preferred choice.

[0009] Towards reducing the cost and as an alternative to the EFI system, in recent times technology in form of Electronic Carburettor System (ECS) has been developed as per known art. While EFI system enables addressing emission issues in both the first and the second regions outlined above, the ECS system primarily addresses the emission in the second reason which is obviously not adequate to reduce the overall emissions. ECS system primarily incorporates one or more bleed circuits into the conventional carburettor which is controlled by a two-stage solenoid through an ECU to control and maintain stoichiometric AF ratio of the charge in the second region of operation. However, a carburettor system is primarily focused on AF mixture control which is a trade-off as compared to the independent control of air and fuel enabled in an EFI system. Thus, carburettor system known in the art including ECS have a technology limitation of not being able to match the emission control achieved by a costly EFI solution. The quality and quantity of mixture cannot be controlled separately in case of a carburettor-based system as known in the art. Thus, a challenge exists of having low cost technology solution which can enable low overall emissions in both the 1st as well as the second regions to enable design of a compact and low-cost vehicle.

[00010] In addition to part cost, there is an increase in cost and complexity of service that has to be addressed. From the service point of view, incorporating an injector required considerable space near the crowded cylinder head region. Taxing this space with additional components can lead to requirement of additional vertical operable clearance space to be able to allow entry of service tools to service the injector & other parts in its vicinity. Thus, any increase or creation of additional space around this region will amount to increasing the overall envelope of space of the power unit making it difficult to achieve a compact design of an engine system. This adversely affects the size of the vehicle is either longitudinal or vertical direction both of which already have layout challenges in achieving a compact vehicle design e.g. vertical height is constrained by seating height to ground clearance requirements & length of vehicle is constrained by wheelbase & vehicle dynamics requirements. Therefore, incorporating complex solutions like EFI typically have an undesirable compromise of the compact layout of the vehicle & or its ease of assembly & service.

DETAILED DESCRIPTION

[00011] In order to keep cost low and simplicity of carburettor retained, as per the present invention, the aspect of cold idle mixture quantity control is achieved by configuring a linear multi-stage proportional solenoid actuator in the choke path of carburetor. The aspect of engine speed control would be achieved with ignition advance and retard implemented with help of an existing engine controller as a software provision with no additional cost. The proportional solenoid actuator is mounted in the manual starter circuit of the conventional VM (variable manifold) carburetor. It has a spring-loaded plunger that when moved linearly from its resting position to fully retracted position, opens two passages, one for air and one for fuel, linearly, thus delivering variable charge mixture in to the engine in a precise controlled manner. The proposed design can be applied to both 2W (two wheeled) and 3W (three wheeled) industries. Also, for other areas of automotive domain where-in proportional control is required.

[00012] Proposed low cost actuator design serves similar functionality as that of a linear stepper actuator typically implemented in an EFI. Such stepper actuator comes at a higher part cost as well as control cost and complexity. Also, the proposed multi-stage actuator retains the proven low cost carburetor body which already houses the choke/enrichment path/circuit providing a basic manual enrichment function. Proposed solution additionally removes any manual intervention and intelligently controls the charge mixture as required by the engine. This provides better functionality for quick catalyst heating, precise lambda value control for emission compliance and ease of use at low cost.

[00013] The operating condition of the engine can be split into two prime regions for simplicity i.e. first region is the cold start or idling region and second region is the high-speed region beyond the warm up limit. While current art is trying to improve an ECS, the basic principle of ECS nowhere helps to address the overall emission reduction especially in the first region of operation. Proposed solution calls for a new actuator design, which is significantly different to already available switching solenoid actuators, achieving the required functionality equivalent of a sophisticated / advanced EFI system at a drastically lower cost and lower complexity. This calls for a multi-disciplinary approach and expertise.

[00014] Proposed emission control system has an intelligent carburetor design comprising of a conventional carburetor with Pilot, Main and Manual Starter circuits, dedicated air-bleed paths as well as switching actuators for Pilot & Main circuits (ECARB version), a Proportional/Linear actuator for starter circuit, an engine controller for all the control action. Switching actuators may be additional implemented for the main circuits in the case of an ECARB version as an additional embodiment. In a conventional carburettor, the engine piston downward movement during intake/suction stroke draws in atmospheric air in to the venturi section thus creating low pressure/vacuum. This negative pressure draws fuel in the bowl and air through metered jets to form a fine air-fuel mixture and this charge is delivered into the intake pipe. The Pilot circuit provides fixed quantity of air-fuel mixture and caters to hot idling and low throttle opening zones of engine operation i.e. first region of operation.

[00015] Main circuit provides regulated air-fuel mixture for low, medium and full throttle operation through a jet needle i.e. both first as well as second region of operation. Additional air-bleed paths for pilot and main circuits facilitate in bleeding vacuum with air thus leaning the air-fuel mixture to desired level. Actuators placed in the air-bleed paths enable precise moderation of the amount of air-bleed quantity. During engine cranking and idling operation in cold temperatures viz. first region of operation, substantial part of air-fuel mixture delivered by pilot circuit (main circuit is not active as throttle is closed) sticks to the cold walls of the intake path. This makes the actual mixture delivered to the combustion chamber very lean and causes unstable operation of engine. Thus, a separate starter circuit providing rich mixture in addition to pilot circuit is configured. This brings air-fuel mixture in the engine to combustible limit and ensures positive starting and idling of the engine. Conventional starter circuits have a manual valve operated by the user through a separate cable other than the throttle cable. Off-late this action has been automated by introducing a two-step solenoid actuator operated by a control unit. In both cases, metering of the air-fuel mixture is very coarse often making the air-fuel mixture very rich as explained earlier.

[00016] Proposed solution has following additional key elements, Proportional/Linear starter actuator comprising a coil, pintle and spring. The spring positions the pintle at its resting position. When electric current passes through the coil it linearly moves the pintle against the spring from its resting position to fully retracted position. With linear movement of the pintle, tapered needle and the starter jet combination deliver fuel in a linear fashion from the bowl, Cylinder of the pintle progressively opens the inlet hole and regulates the engine vacuum in the starter circuit, both the above actions result in linear delivery of air-fuel mixture into the outlet hole of starter circuit. The engine controller monitors sensors providing information of the engine such as engine speed, throttle position, engine and/or air temperature & AFR/LAMBDA value of exhaust gas etc. and controls actuators such as ignition coil thereby ignition timing and linear starter actuator to deliver instantaneous target value of air-fuel mixture.

[00017] Cold-start and idling zone emissions contribute to 70-80% of total pollutant emission in a typical WMTC drive cycle which is used for a typical low cost compact saddle type vehicle to check for emissions. This poses a big challenge on the design, sizing, cost & time to light-off characteristics of after-treatment devices like catalyst. Thus, it is very necessary to control the air-fuel mixture during cold-start & idling operation of the engine to ensure both hassle free operation and emission reduction of the vehicle. This brings us to the present invention which has an intelligent carburetor device with a robust control mechanism to start & idle the vehicle in cold condition, this is achieved by fine control of air-fuel mixture delivered from starter circuit by linear actuator and reduce emissions by fast heat-up of catalyst for early light-off which is achieved by delayed combustion increasing the exhaust gas temperature which heats-up the catalyst to reach target light-off temperature at a faster rate.

[00018] Invention intends to achieve low overall emissions in both the first as well as the second operating regions. The intelligent carburetor system aims to achieve functionality of precise air-fuel mixture control in engine cold start & idle condition in a conventional carburetor at low cost (as compared to electronic fuel injection systems), achieve early light-off characteristics of catalyst by exhaust gas heating and along with precise air-fuel mixture control as achieved above thereby increasing its conversion efficiency to reduce cold phase emissions significantly.

[00019] Towards achieving the target overall low emissions, the Engine Controller's control flow is additionally configured with a step-wise method with the functionality of the design as described below in following steps, determine that the engine is starting in cold condition, by constantly monitoring the engine/air temperature, determines the engine is in cranking or idling condition by constantly monitoring engine speed & throttle position, actuates the linear starter actuator to provide regulated quantity of air-fuel mixture through starter circuit, measures the AFR/LAMBDA of exhaust gas using exhaust gas oxygen sensor continuously, continuously adjust the linear starter actuator position in closed loop control mode to maintain LAMBDA =1, continuously adjusts ignition timing in closed loop control mode to idle the engine at higher speed band. Above steps heats-up the catalyst quickly reaching its light-off point and the air-fuel mixture which is maintained at LAMBDA = 1, helps the catalyst to operate at its peak conversion efficiency at the earliest possible time from the start of the engine.

[00020] Thus with catalyst made to operate at its efficient operating point early in the cold phase of the engine running, cold start & idle emissions can be effectively controlled. Once engine temperature increases beyond a set threshold value and/or engine speed and throttle position increases beyond set threshold values, linear starter actuator is progressively moved back to its resting position and ignition timing is adjusted as per the calibrated values for normal operation condition of the engine.

[00021] Also, air-fuel mixture control in the engine operating condition as described above is guided by the pilot and main circuit carburetor as tuned, thus ensuring normal operation of the engine.

[00022] 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. Therefore, within the scope of claims of the present subject matter, the present disclosure may be practiced other than as specifically described.

[00023] As per an embodiment, the total travel of the tapered spindle in in the range of 3mm to 5 mm for best performance. As per an embodiment, the intelligent carburetor system along with ECU is configured to operate in the 2nd region with Lambda = 1 with 50% of the total travel of the spindle in the temperature above 16 degrees Celsius. As per another aspect of the same embodiment, the system is configured to operate with a rich charge of AF mixture with Lambda less than 0.8 within a temperature range from -10 degrees to 16 degrees.

[00024] The aforesaid and other advantages of the present subject matter would be described in greater detail in conjunction with an embodiment of an emission control system with the figures in the following description.

[00025] **Figure 1** illustrates perspective view of an intelligent carburetor assembly with additional air bleed paths and proportional solenoid as per the present invention. An emission control system as per the present invention has an intelligent carburetor assembly **(100)** design comprising of a conventional carburetor with a pilot circuit **(105)** (shown in **Figure 4**), a main circuit **(110)** (shown in **Figure 5**) and a manual starter circuit **(115)** (shown in **Figure 2**), one or more dedicated air-bleed path **(120a, 120b)**, one or more actuators **(125a, 125b)** (not shown) for said pilot circuit **(105)** and said main circuit **(110)** (shown in **Figure 5**) (ECARB version), a proportional/linear actuator **(130)** for said manual starter circuit **(115)** and an engine controller (not shown) for all the control action. As per an embodiment of the present invention said one or more actuators **(125a, 125b)** are switching actuators connected to said one or more dedicated air-bleed path **(120a, 120b)**. As per an embodiment of the present invention said one or more actuators **(125s, 125b)** are additionally implemented for said pilot circuit **(105)** and said main circuit **(125b)** in the case of an ECARB version as an additional embodiment.

[00026] In a conventional carburetor, the engine piston downward movement during intake/suction stroke draws in atmospheric air in to a venturi section thus creating low pressure/vacuum. This negative pressure draws fuel in the bowl as well as air through metered jets to form a fine air-fuel mixture and this charge is delivered into the intake pipe. The operating condition of the engine can be split into two prime regions for simplicity i.e. first region is the cold start or idling region and second region is the high-speed region beyond the warm up limit. As per the present invention, said Pilot circuit **(105)** provides fixed quantity of air-fuel mixture and caters to hot idling and low throttle opening zones of engine operation i.e. first region of operation. Additional air-bleed paths

(120a, 120b) for said pilot circuit **(105)** and said main circuit **(110)** facilitate in bleeding vacuum with air thus leaning the air-fuel mixture to desired level. Said one or more actuators **(125a, 125b)** placed in said air-bleed paths **(120a, 120b)** enable precise and desired moderation of the amount of air-bleed quantity.

[00027] **Figure 2** illustrates sectional side view of said proportional/linear starter actuator **(130)** as per an embodiment of the present invention. Accordingly, said proportional/linear starter actuator **(130)** includes a coil, a spring positioned inside a coil and spring housing **(205)** and a pintle **(210)**. According to an embodiment of the present invention, said spring positions said pintle **(210)** at its resting position. When an electric current passes through said coil, said coil linearly moves said pintle **(210)** against said spring from the resting position to a fully retracted position. With the linear movement of said pintle **(210)**, a tapered needle **(215)** and a starter jet (not shown) in combination deliver fuel in a linear fashion from a bowl. According to an embodiment of the present invention a cylinder **(225)** of said pintle **(210)** progressively opens an inlet hole as well as regulates the engine vacuum in said manual starter circuit **(115)** (shown in **Figure 2**); both the above actions together result in a linear delivery of air-fuel mixture into an outlet hole of said manual starter circuit **(115)**. As per an embodiment, the total travel of said tapered needle **(215)** in in the range of 3mm to 5 mm for best performance. As per an embodiment, said intelligent carburetor system **(100)** along with ECU is configured to operate in the second region with Lambda = 1 with 50 percent of the total travel of the spindle in the temperature above 16 degrees Celsius. As per another aspect of the same embodiment, the system is configured to operate with a rich charge of AF mixture with Lambda less than 0.8 within a temperature range from -10 degrees to 16 degrees. As per an embodiment of the present invention said proportional/ linear starter actuator **(130)** has a spring **(205b)**-loaded plunger that when moved linearly from its resting position to fully retracted position, opens two passages (as shown in **Figure 3)** shown as **IA** inlet air and **F** for fuel

(shown in **Figure 3**), thus delivering variable charge mixture in to the engine in a precise and intelligently controlled manner.

[00028] **Figure 3** illustrates a sectional side-view of a top portion of said intelligent carburetor assembly **(100)** indicating proportional solenoid and manual starter circuit path. According to an embodiment of the present invention, **IA** is the air coming from the air intake. **F** is direction of the fuel entering and thereby generating air fuel mixture **AF**.

[00029] **Figure 4** illustrates a perspective view of said intelligent carburetor assembly **(100)** indicating said pilot circuit **(105)** and additional pilot air bleed path **(120a)**. Accordingly, as shown in Figure 4, the direction of the arrow **AA** represents the air entering from said actuator **(125a)** (not shown). Arrow **IA** represents air coming through said additional pilot air bleed path **(120a)** from the air intake and arrow direction **F** represents the fuel entering said intelligent carburettor assembly **(100)**.

[00030] **Figure 5** illustrates a perspective sectional view of said intelligent carburetor assembly **(100)** indicating said main circuit **(110)** and said additional main air bleed path **(120b)**. Accordingly, as shown in Figure 5, the direction of the arrow **AA'** represents the air entering from said actuator **(125b)** (not shown). Arrow **IA** represents air coming through said additional main air bleed path **(120b)** from the air intake and arrow direction **F** represents the fuel entering the sub-assembly **(100c)**.

[00031] As per an embodiment of the present invention said engine controller monitors one or more sensors providing information of the engine such as engine speed, throttle position, engine and/or air temperature and AFR/LAMBDA value of exhaust gas etc. and said engine controller controls actuators such as ignition coil thereby ignition timing and linear starter actuator to deliver instantaneous target value of air-fuel mixture.

[00032] **Figure 6** illustrates a flow-chart depicting the engine control system algorithm flow. As per an embodiment of the present invention said intelligent carburetor assembly **(100)** is configured with a robust control mechanism to start and idle the vehicle in cold condition, this is achieved by fine control of air-fuel mixture delivered from said manual starter circuit (**115**) by said linear actuator (**130**) and reduce emissions by fast heat-up of catalyst for early light-off which is achieved by delayed combustion leading to increase of the exhaust gas temperature which heats-up the catalyst to reach target light-off temperature at a faster rate.

[00033] Towards achieving the target overall low emissions, said engine controller's (not shown) control flow is additionally configured with a step-wise method with the functionality of the design as described below in following steps, at first, measure the input from a crankshaft speed sensor and an engine temperature sensor in order to determine that the engine is starting in cold condition (first region of operation) (the engine is in cranking or idling condition), by constantly monitoring the engine/air temperature (step **500**). Calculating the engine speed (via crankshaft sensor) and temperature by converting the voltage generated by the sensors (step **505**). Next step (step **510**) is to check the engine speed, if the engine speed is less than or equal to the idling speed then the process flows to the next step **(515)** and if the engine speed is greater than the idling speed then the process flows to step **540** where said proportional solenoid (**130**) is retracted to resting position and reverted to standard ignition timing. When the engine speed is less than or equal to the idling speed in step **510** then the process flows to the next step (**515**). In step **515**, the engine temperature is checked, if the engine temperature is less than or equal to the threshold temperature, the process flows to next step (step **520)** and if the engine temperature is greater than the threshold temperature then the process flows to step **540** where said proportional solenoid (**130**) is retracted to resting position and reverted to standard ignition timing.

[00034] In step **520** as shown in the flow diagram, the input from the exhaust gas oxygen sensor is taken and the AFR/LAMBDA is measured. As per an embodiment of the present invention, the exhaust gas oxygen sensor is a narrowband oxygen sensor. A narrowband oxygen sensor works on a rich/lean principle. For example, generally, the AFR Stoichiometric ratio is14.7 for 0.45 Volts on sensor. The richer side voltage will be 0.8 Volts and 0.2 Volts for lean side, at this voltage the sensor will switch to lean side. For some sensors 0.8 Volts and 0.2 Volts can get inverted in terms of the AFR for instance 0.8

Volts can become for lean side and 0.2 Volts can be rich side. In step **520a** the value of AFR and LAMBDA is calculated. The next step (step **525**) is to check whether the AFR = 14.7 or LAMBDA =1, if the condition is TRUE then move to step **530** and hold the position of said proportional solenoid (**130**). If at step **525** the AFR is not equal to 14.7 or LAMBDA is not equal to 1 then continuously adjust said linear starter actuator (**130**) position in closed loop control mode to maintain AFR = 14.7 or LAMBDA =1 (step **535**).

[00035] Above steps heats-up the catalyst quickly reaching its light-off point and the air-fuel mixture which is maintained at LAMBDA = 1, helps the catalyst to operate at its peak conversion efficiency at the earliest possible time from the start of the engine thereby achieving desired performance of the engine as well as reduced emissions through efficient combustion.

[00036] The present invention intends to achieve low overall emissions in both the first as well as the second operating regions as explained above. Said intelligent carburetor system (**100**) aims to achieve functionality of precise air-fuel mixture control in engine during cold start as well as in idle condition in a conventional carburetor (as compared to electronic fuel injection systems). Further, said intelligent carburetor system (**100**) aims to achieve early light-off characteristics of catalyst by exhaust gas heating. Also, a precise air-fuel mixture control is achieved above thereby increasing its conversion efficiency to reduce cold phase emissions significantly. Thus with catalyst made to operate at its efficient operating point early in the cold phase of the engine running, cold start & idle emissions can be effectively reduced / controlled. Once engine temperature increases beyond a set threshold value and/or engine speed and throttle position increases beyond set threshold values, said linear starter actuator (**130**) is progressively moved back to its resting position and ignition timing is adjusted / reset as per the calibrated values for normal operation condition of the engine.

List of Reference Signs

100	Intelligent Carburetor Assembly
105	Pilot circuit
110	Main circuit
115	Manual Starter circuit
120a, 120b	One or more dedicated air-bleed path
125a, 125b	One or more actuators
130	Proportional/linear actuator
205	Coil and spring housing
210	Pintle
215	Tapered Needle
220	Cylinder of Pintle

We Claim:

1. An emission control system comprising:
an intelligent carburetor assembly **(100)** having a carburetor with a pilot circuit **(105)**, a main circuit **(110)** and a manual starter circuit **(115)**;
one or more dedicated air-bleed paths **(120a, 120b)**;
one or more actuators **(125a, 125b)**;
a proportional/linear actuator **(130)** for said manual starter circuit **(115)**;
an engine controller for monitoring one or more sensors;
wherein said engine controller controls said one or more actuators **(125a, 125b)**, said linear starter actuator **(130)** and the ignition timing to deliver instantaneous target value of air-fuel mixture.
2. The emission control system as claimed in claim 1 wherein, one or more actuators **(125a, 125b)** are connected to said pilot circuit **(105)** and said main circuit **(115)**.
3. The emission control system as claimed in claim 1 wherein, said sensors provide information of the engine to said engine controller and said information consists of the engine speed, throttle position, engine and/or air temperature and AFR/LAMBDA value of exhaust gas.
4. The emission control system as claimed in claim 1 wherein, said intelligent carburetor assembly **(100)** along with the ECU is configured to operate, in the region where Lambda is equal to 1, with 50 percent of the total travel of said spindle in the temperature above 16 degrees Celsius.
5. The emission control system as claimed in claim 1 wherein, said emission control system is configured to operate with a rich charge of air fuel mixture where Lambda less than 0.8, within a temperature range from -10 degrees to 16 degrees.
6. The emission control system as claimed in claim 1 wherein, said linear starter actuator **(130)** position being adjusted in a closed loop control mode to maintain AFR= 14.7 or LAMBDA =1.
7. A method of controlling emission for an internal combustion engine, said method comprising:

measuring the input from a crankshaft speed sensor and an engine temperature sensor in order to determine that the engine is starting in cold condition (the engine is in cranking or idling condition), by constantly monitoring the engine/air temperature (step **500**);

calculating the engine speed via crankshaft sensor and temperature by converting the voltage generated by the sensors (step **505**);

checking the engine speed, if the engine speed is less than or equal to the idling speed (step **510**) then the process flows to step **515,** if the engine speed is greater than the idling speed then the process flows to step **540** where said proportional solenoid (**130**) is retracted to resting position and reverting to standard ignition timing;

checking the engine temperature, if the engine temperature is less than or equal to the threshold temperature (step **515**), the process flows to step **520,** if the engine temperature is greater than the threshold temperature then the process flows to step **540** where said proportional solenoid (**130**) is retracted to resting position and reverting to standard ignition timing;

measuring the input from the exhaust gas oxygen sensor for determining value of AFR/LAMBDA (step **520**);
calculating the value of AFR and LAMBDA (step **520a**);
checking whether the AFR = 14.7 or LAMBDA =1 (step **525**), if the condition is TRUE then move to step **530** and hold the position of said proportional solenoid (**130**) and if at step **525** the AFR is not equal to 14.7 or LAMBDA is not equal to 1 then continuously adjust said linear starter actuator (**130**) position in closed loop control mode to maintain AFR = 14.7 or LAMBDA =1 (step **535**).

8. The method of controlling emission for an internal combustion engine as claimed in claim 6 wherein, said exhaust gas oxygen sensor is a narrowband exhaust oxygen sensor.

9. An emission control system having a linear multi-stage proportional solenoid actuator (**130**) positioned in the choke path of an intelligent carburettor assembly (**100**).

10. A proportional/linear starter actuator (**130**) for an intelligent carburetor assembly (**100**), said proportional/linear starter actuator (**130**) comprising:

a coil (**205a**), a spring (**205b**) a pintle (**210**) and a tapered needle (**215**), said spring (**205b**) positions said pintle (**210**) at its resting position;

wherein on passing of electric current through said coil (**205a**), said spring (**205b**) linearly moves said pintle (**210**) against said spring (**205b**) from the resting position to a fully retracted position;

wherein a cylinder (**225**) of said pintle (**210**) progressively opens an inlet hole and regulates the engine vacuum in a manual starter circuit (**115**).

11. The proportional/linear starter actuator (**130**) as claimed in claim 10 wherein, said coil (**205a**) and said spring (**205b**) are positioned in a coil and spring housing (**205**).

12. The proportional/linear starter actuator (**130**) as claimed in claim 10 wherein, the total travel of said tapered needle (**215**) is in the range of 3mm to 5 mm.

13. The proportional/linear starter actuator (**130**) as claimed in claim 10 wherein, said proportional/ linear starter actuator (**130**) has a spring (**205b**)-loaded plunger configured to move linearly from its resting position to fully retracted position, opens two passages **IA** for inlet air and **F** for fuel, delivering variable charge mixture in to the engine in a precise controlled manner.

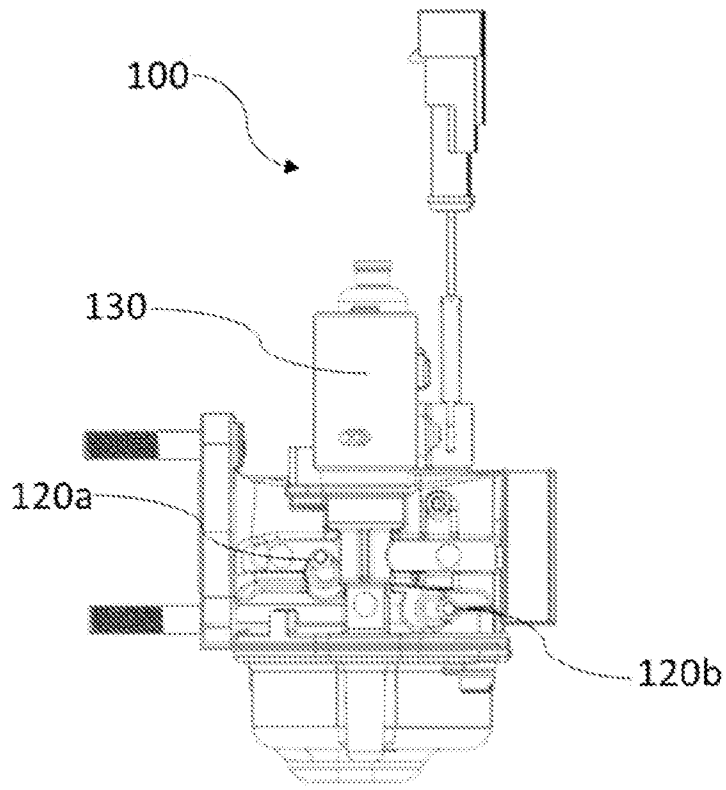

Figure 1

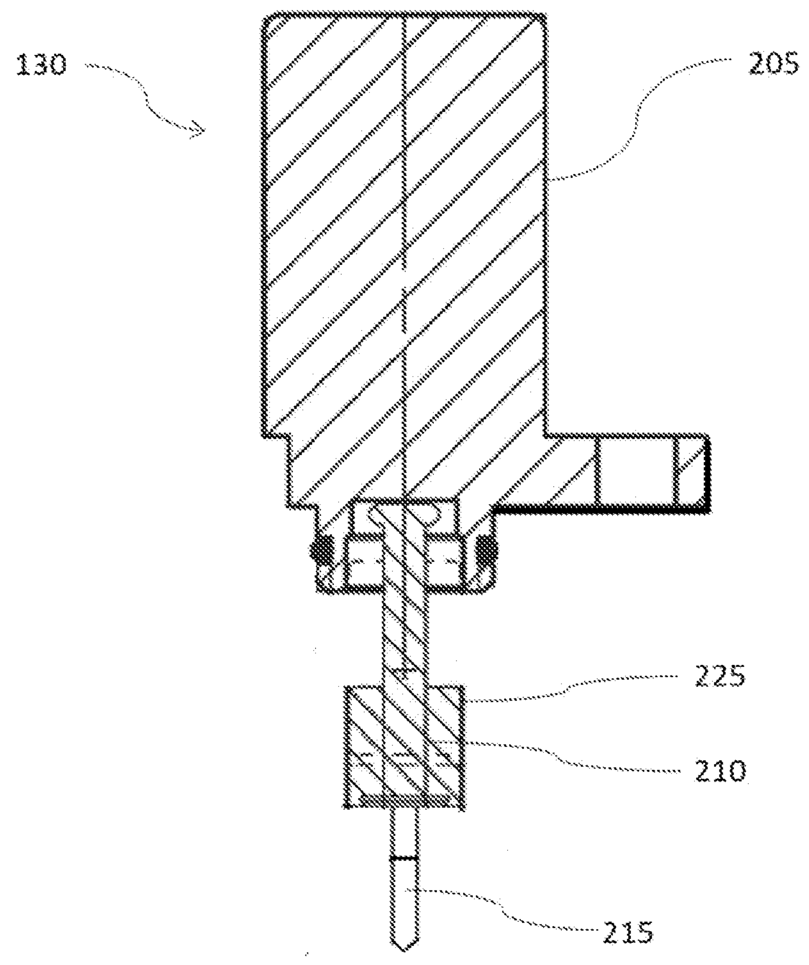

Figure 2

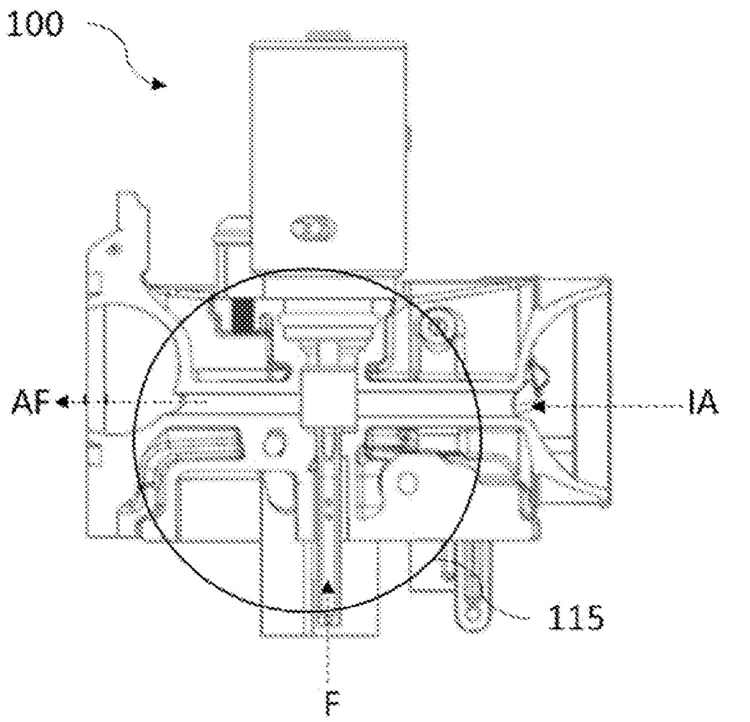

Figure 3

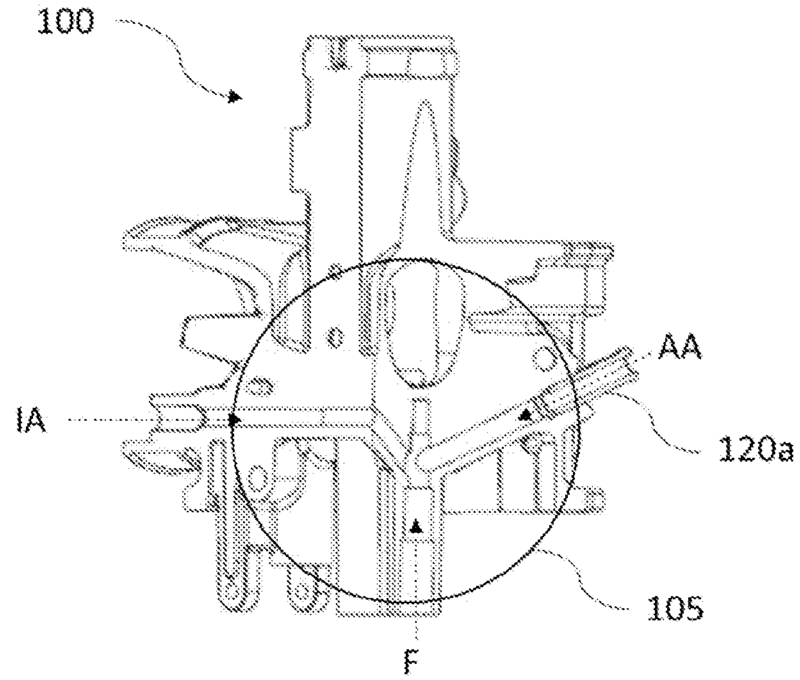

Figure 4

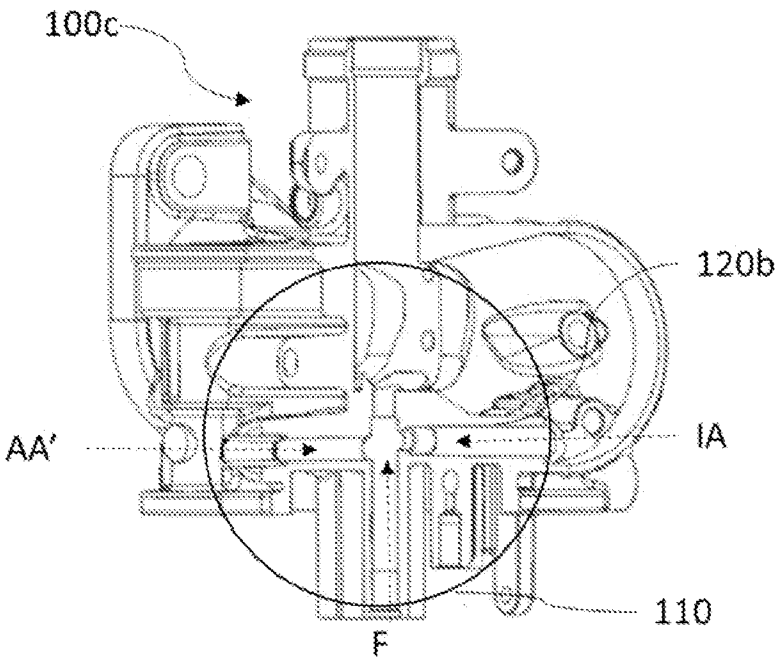

Figure 5

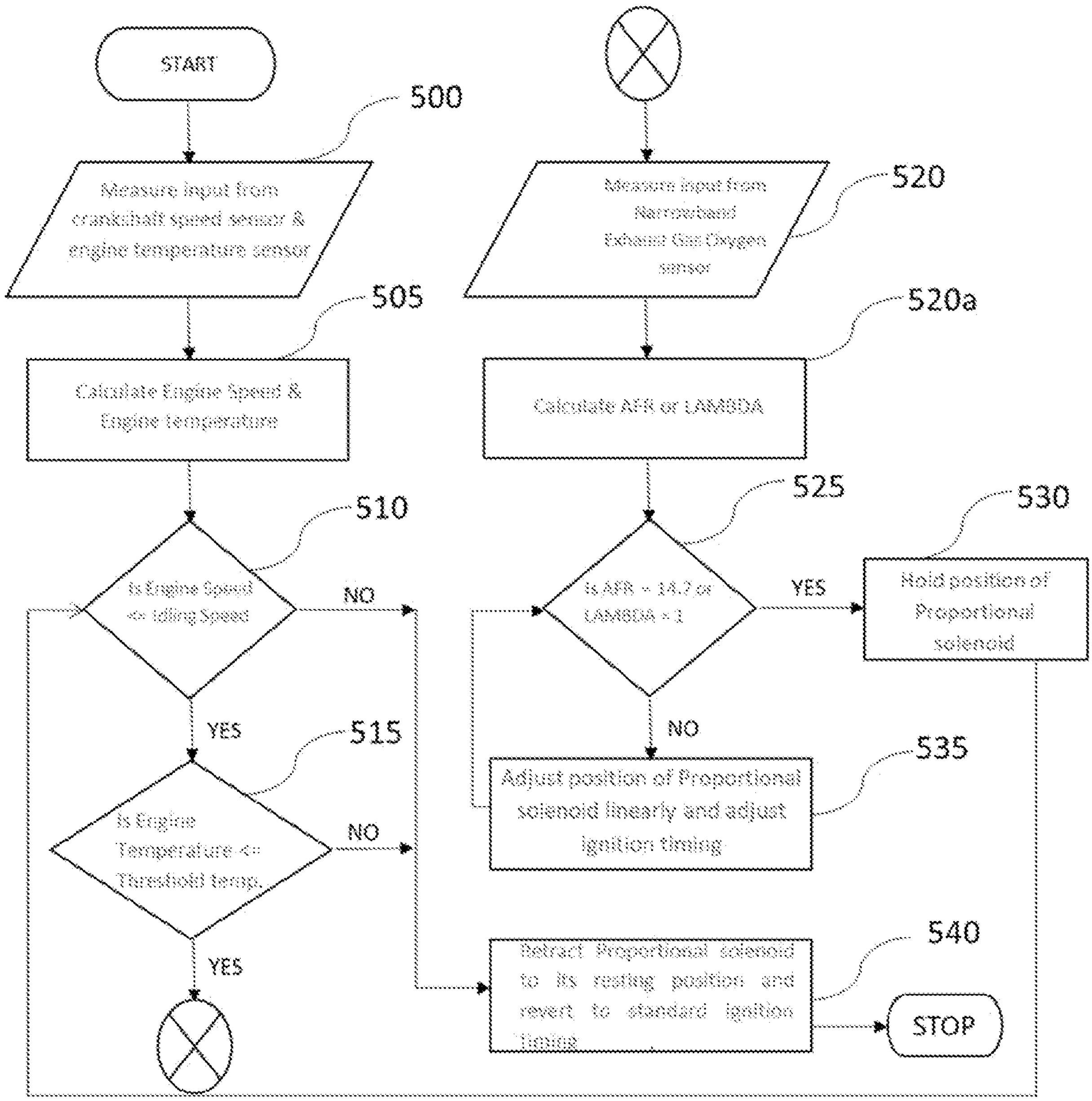
START
500
Measure input from crankshaft speed sensor & engine temperature sensor
505
Calculate Engine Speed & Engine temperature
510
Is Engine Speed <= Idling Speed
NO
YES
515
Is Engine Temperature <= Threshold temp.
NO
YES
520
Measure input from Narrowband Exhaust Gas Oxygen sensor
520a
Calculate AFR or LAMBDA
525
Is AFR = 14.7 or LAMBDA = 1
YES
530
Hold position of Proportional solenoid
NO
535
Adjust position of Proportional solenoid linearly and adjust ignition timing
540
Retract Proportional solenoid to its resting position and revert to standard ignition timing
STOP

Figure 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IN2021/050237

A. CLASSIFICATION OF SUBJECT MATTER
INV. F02D35/00 F02D41/00 F02D41/06 F02D41/14 F02D41/20
F02M1/08
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)
F02D F02M

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2016/377009 A1 (KLECZEWSKI MICHAEL ROBERT [US] ET AL) 29 December 2016 (2016-12-29) abstract paragraph [0002] paragraph [0053] figure 1 -----	1-13
X	GB 2 077 359 A (ORFORD JOHN REGINALD) 16 December 1981 (1981-12-16) the whole document -----	10-13

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 July 2021	22/07/2021

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IN2021/050237

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		US 2016377009 A1	29-12-2016
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