



(51) International Patent Classification:
F02M 31/13 (2006.01)

(21) International Application Number:
PCT/US2011/021827

(22) International Filing Date:
20 January 2011 (20.01.2011)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant (for all designated States except US): **INTERNATIONAL ENGINE INTELLECTUAL PROPERTY COMPANY, LLC** [US/US]; 4201 Winfield Road, Warrenville, Illinois 60555 (US).

(72) Inventor; and

(71) Applicant : **JIA, Donghong** [CN/US]; 6S551 Naper Blvd., #12, Naperville, Illinois 60540 (US).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **ZHANG, Guoqing** [CN/US]; 2980 Burlington Avenue, Lisle, Illinois 60532 (US).

(74) Agent: **NIMZ, Jack, D.**; 4201 Winfield Road, Warrenville, Illinois 60555 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to the identity of the inventor (Rule 4.17(i))
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

Published:

- with international search report (Art. 21(3))

(54) Title: FUELING BASED ON INTAKE TEMPERATURE

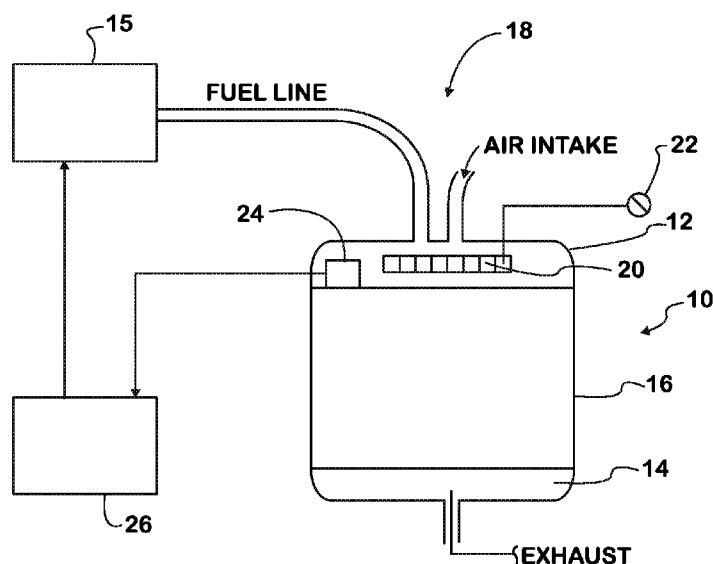


FIG. 1

(57) Abstract: A method and system for improving air/fuel ratios for in cold start of an engine is disclosed. The method includes sensing an engine startup operation, providing intake air at ambient temperature, providing quantity of start fuel required for startup, increasing temperature of intake air to a target, and determining a ratio of start fuel to intake air needed to start engine based on intake air temperature. The system includes a heater for attachment to or near an intake manifold of the engine, a control device for operating the heater, at least one sensor for determining temperature of intake air, and a control module connected to the sensor for determining amount of fuel required for engine cold start based on temperature of intake air.

FUELING BASED ON INTAKE TEMPERATURE

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to air/fuel control for an internal combustion engine, and more particularly, to an improved air/fuel ratio control and cold start intake air preheat system for assisting in the cold start of a diesel engine.

BACKGROUND OF THE INVENTION

[0002] Cold fuel temperatures are known to result in severe degradation of atomization quality and fuel vaporization rate. These effects result in the need to utilize enrichment strategies to guarantee stable operation of the cold engine. Enrichment strategies typically require that fuel in excess of that required for normal engine operation be injected at the start of the engine to ensure that enough fuel vapor is available in the combustion chamber. Thus, cold start of a diesel engine, for example, typically requires dumping a large quantity of fuel at the cranking period, and gradually stepping down once the engine reaches the desired idle speed.

[0003] The need for improving the fuel-air mixture in the combustion chamber has been recognized for many years. One attempted solution to this need has been to install electrically heated fuel injectors in the internal combustion engine to preheat and improve atomization of the fuel. Preheating permits prompt starting of the engine even at lower ambient temperatures, as well as, contributes to the reduction of hydrocarbon emissions upon start-up. However, there is a need for improved control of air/fuel ratios and preheater systems without the need for using excess fuel during cold start for better start reliability and lower hydrocarbon emissions through lower fuel requirements during cold start-up.

SUMMARY OF THE INVENTION

[0004] There is disclosed herein an improved method and control system for improving air/fuel ratios relating to the cold start of a diesel engine, which avoids disadvantages of prior methods, while affording additional operating advantages.

[0005] In an embodiment of the invention, a method for controlling the fuel/air ratio during a cold start for an internal combustion engine is disclosed. The method includes the steps of, sensing an engine startup operation, providing intake air at an engine air intake manifold at an ambient temperature, providing a quantity of start fuel required for engine

startup, providing a heating device for increasing the temperature of the intake air to a target level, and determining a ratio of start fuel to intake air needed to start the engine based on the temperature of the intake air.

[0006] In yet another embodiment of the present invention, the method further comprises the step of increasing the temperature of the intake air to above the ambient air temperature thereby reducing the ratio of start fuel to intake air.

[0007] In another embodiment of the present invention, a cold start intake air preheat system for use in assisting with the cold start of an engine, is provided. The system includes an air intake manifold for the engine, a heating device for attachment to the air intake manifold, the heating device capable of heating the intake air to a desired temperature. The system also includes a control device for operating the heating device between an on and an off position, at least one temperature sensor for determining the temperature of the intake air and, an electronic control module connected to the sensor, wherein the electronic control module is capable of determining an amount of fuel from a fuel system required for the cold start of the engine based on the temperature of the intake air reading from the temperature sensor.

[0008] These and other aspects of the invention may be understood more readily from the following description and the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] For the purpose of facilitating an understanding of the subject matter sought to be protected, there are illustrated in the accompanying drawings embodiments thereof, from an inspection of which, when considered in connection with the following description, the subject matter sought to be protected, its construction and operation, and many of its advantages should be readily understood and appreciated.

[0010] FIG. 1 is a schematic diagram of an engine and embodiment of the cold start intake air preheat system of the present invention.

[0011] FIG. 2 is a graph showing the dynamics between coolant temperature, intake air temperature and fuel delivery at start-up.

[0012] FIG. 3 is a graph showing the dynamics between intake air heating being higher than the coolant temperature, and the same fuel delivery during start-up as FIG. 1.

[0013] FIG. 4 is a graph showing the dynamics between the temperature of the intake air being the same as coolant, and the increased fuel delivery during start-up.

DETAILED DESCRIPTION OF THE INVENTION

[0014] While this invention is susceptible of embodiments in many different forms, there is shown in the drawings and will herein be described in detail a preferred embodiment of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspect of the invention to embodiments illustrated.

[0015] Referring to FIG. 1, there is illustrated a typical internal combustion engine 10. Since its operation is well known, the details of the engine 10 will only be briefly outlined as it relates to the present invention. For example, an internal combustion engine 10 includes an air intake manifold 12 and an exhaust manifold 14, both operatively connected to the engine block 16. Intake air passing through the intake manifold 12 is combined with injected fuel from a fuel system 15 to form an air-fuel mixture in the combustion chambers (not shown). In a standard diesel powered combustion engine, for example, compressed intake air is sent into a combustion chamber and is compressed to a high compression ratio. Fuel is then sprayed through fuel injectors (not shown) to the compressed intake air for combustion of the fuel by making use of heat generated from a higher compression ratio to ignite spontaneously, thus causing a piston to move up and down (not shown). The rate of fuel delivery may be regulated by a mechanical or electronic governor (not shown) which regulates idle speed and maximum speed of the engine by controlling the rate of fuel delivery. It is well-known that during the cold start process, excess fuel is typically used. Thus, during cold start-up, it is believed it would be useful to heat the air in the intake system of the engine 10 as a combustion aid to avoid the excess fuel requirement.

[0016] As illustrated in FIG. 1, in an embodiment of the present invention, preheating of intake air is accomplished through a cold start intake air preheat system 18. The intake air preheat system 18 includes a heating device 20 for heating the intake air at the air intake manifold 12, a control device 22 for operating the heating device between an "on" and an "off" position, at least one sensor or a series of sensors 24 such as temperature sensors, for determining the temperature of the intake air at the air intake manifold, and a microprocessor-based engine control module (ECM) 26 for determining an amount of fuel required for cold start of the engine based on the temperature of the intake air.

[0017] The heating device 20 may include any heating device, which can be easily installed within, on, or proximate to, the air intake manifold 12 of the engine 10. Suitable

heating devices 20 may include a heating block, resistive grid heaters, or other heating elements that may be known to those skilled in the art. It would be advantageous that the heating device 20 heat instantaneously when switched on. It is contemplated that the heating device 20 would obtain its power from a battery (not shown) of the engine 10.

[0018] A control device 22 may include any form of suitable control device known in the art, including but not limited to, a switch. The control device 22 would activate the heating device, preferably to an "on" position prior to the start-up of the engine. For example, the driver entering the cab of the vehicle would flip a toggle switch or push a button acting as the control device 22 to activate the heating device 20 just prior to turning the ignition switch to start the engine 10. Optionally, the heating device 20 may also be in a constant "on" or standby position, so that it is activated when the ignition of the engine is turned on.

[0019] The system 18 also includes at least one sensor or a series of sensors 24, preferably temperature sensors, which would be linked to the ECM 26 in a known manner. The sensor or sensors 24 are used to read the temperature of the intake air at the intake manifold 12, which is then relayed to the ECM 26. Based on the temperature reading of the intake air, the ECM 26 determines whether additional fuel is needed to assist in the start of the engine. If, based on the sensor 24 readings, the intake air temperature is not at a specific reading, the information is relayed through the ECM 26 to the fuel system 15, and a spike in additional fuel is injected at start-up in order to start the engine. On the contrary, should the sensors 24 indicate that the temperature of the intake air is above a certain level, such as above the temperature of the coolant and/or the ambient temperature, the ECM 26 will not signal the fuel system 15 to provide the additional fuel spike otherwise required during a typical cold start. Sensors 24 useful in the present invention can be any type known in the art, and already employed in most engines.

[0020] The fuel injection system 15 and other electronic sub-systems of the engine 10 are controlled by the ECM 26 in response to various inputs. Various inputs pertinent to the fuel control and engine operations, and which may also be utilized in the present invention, include the intake manifold absolute pressure (MAP), the engine speed (ES), the engine coolant temperature (CT), the exhaust gas oxygen signal (O2), and the ignition state (IGN_STATE). Again, such input signals are obtained with conventional sensors well known to those skilled in the art.

[0021] In general, the ECM 26 determines an appropriate quantity of fuel to be injected based on a measure or estimation of the ingested inlet mass air flow temperature and a target air/fuel ratio for combustion in the engine cylinders. During cold starting and warm-up of the

engine 10, the exhaust gas oxygen sensor (not shown) is inoperative, and the fuel injection quantity is determined in an open-loop manner based on the above mentioned inputs to produce an open-loop air/fuel. Such ratio may be somewhat richer than the stoichiometric ratio as indicated since the internal surfaces of engine 10 are initially too cool to completely vaporize the injected fuel.

[0022] The present invention makes use of the benefit of increasing the temperature of intake air at the air intake manifold 12 and its effect on decreasing the amount of fuel required during a cold start. This concept is illustrated in FIGS. 2-4. FIG. 2 is a conceptual graph illustrating that during a typical cold start, when the intake air temperature 28 is the same as the coolant temperature 30, and regardless of the amount of fuel delivery 32, the engine will not start, as shown by the overall decrease in engine speed 34. FIG. 3, which is an illustrative embodiment of the present invention, shows that when the intake air temperature 28 is heated to a temperature greater than that of the coolant temperature 30, subsequent fuel delivery 32 results in the engine starting. The scenario of FIG. 3 shows that a spike in fuel is not required to start the engine. FIG. 4 is a conceptual graph illustrating that when the intake air temperature 28 and the coolant temperature 30 are the same, the engine will start with a substantial initial spike in the amount of fuel. Again, while the scenario of FIG. 4 results in the engine start-up, it is not the ideal situation, as the excess fuel required at start-up remains effectively unburned, and may result in higher hydrocarbon emissions.

[0023] The matter set forth in the foregoing description and accompanying drawings is offered by way of illustration only and not as a limitation. While particular embodiments have been shown and described, it will be apparent to those skilled in the art that changes and modifications may be made without departing from the broader aspects of applicants' contribution. The actual scope of the protection sought is intended to be defined in the following claims when viewed in their proper perspective based on the prior art.

CLAIMS

What is claimed is:

1. A method for controlling the fuel/air ratio during a cold start for an internal combustion engine, the method comprising the steps of:

sensing an engine startup operation;

providing intake air at an engine air intake manifold at an ambient temperature;

providing a quantity of start fuel required for engine startup;

providing a heating device for increasing the temperature of the intake air to a target level; and,

determining a ratio of start fuel to intake air needed to start the engine based on the temperature of the intake air.

2. The method of claim 1, wherein the step of providing a heating device for increasing the temperature of the intake air includes providing the heating device within the intake manifold.

3. The method of claim 2, wherein the method the step of providing a heating device for increasing the temperature of the intake air includes providing the heating device proximate to the intake manifold.

4. The method of claim 1, wherein the method further comprises the step of increasing the temperature of the intake air to above the ambient air temperature.

5. The method of claim 4, wherein the step of increasing the temperature of the intake air to above the ambient air temperature reduces the ratio of start fuel to intake air.

6. A method for assisting in the cold start of an internal combustion engine, the method comprising the steps of:

sensing an engine startup operation;

providing intake air through an engine air intake manifold;

providing an appropriate start fuel quantity;

sensing a temperature of the intake air;

calculating a ratio of intake air to start fuel quantity based on the temperature of the intake air; and,

adjusting the quantity of the start fuel based on the calculated ratio of intake air to start fuel quantity to start the engine.

7. The method of claim 6, wherein the method further comprises the step of providing a heating device proximate to the air intake manifold to increase the temperature of the intake air by passing the intake air through the heating device.

8. The method of claim 7, wherein the step of increasing the temperature of the intake air includes increasing the temperature to above the ambient air temperature.

9. The method of claim 6, wherein the step of adjusting the quantity of the start fuel includes reducing the quantity of the start fuel when the temperature of the intake air increases.

10. A cold start intake air preheat system for use in assisting in the cold start of an engine, the system comprising:

an air intake manifold for the engine;

a heating device for attachment to the air intake manifold, the heating device capable of heating the intake air to a desired temperature;

a control device for operating the heating device between an on and an off position;

at least one temperature sensor for determining the temperature of the intake air; and,

a electronic control module connected to the sensor, wherein the electronic control module is capable of determining an amount of fuel from a fuel system required for the cold start of the engine based on the temperature of the intake air reading from the temperature sensor.

11. The intake air preheat system of claim 10, wherein the heating device is positioned proximate to the air intake manifold.

12. The intake air preheat system of claim 11, wherein the heating device is capable of heating the intake air to above the ambient temperature.

13. The intake air preheat system of claim 10, wherein the temperature sensor comprises a series of sensors for determining the temperature of the intake air.

14. The intake air preheat system of claim 10, wherein the electronic control module determines a decreased amount of start fuel required to start the engine when the intake air temperature increases.

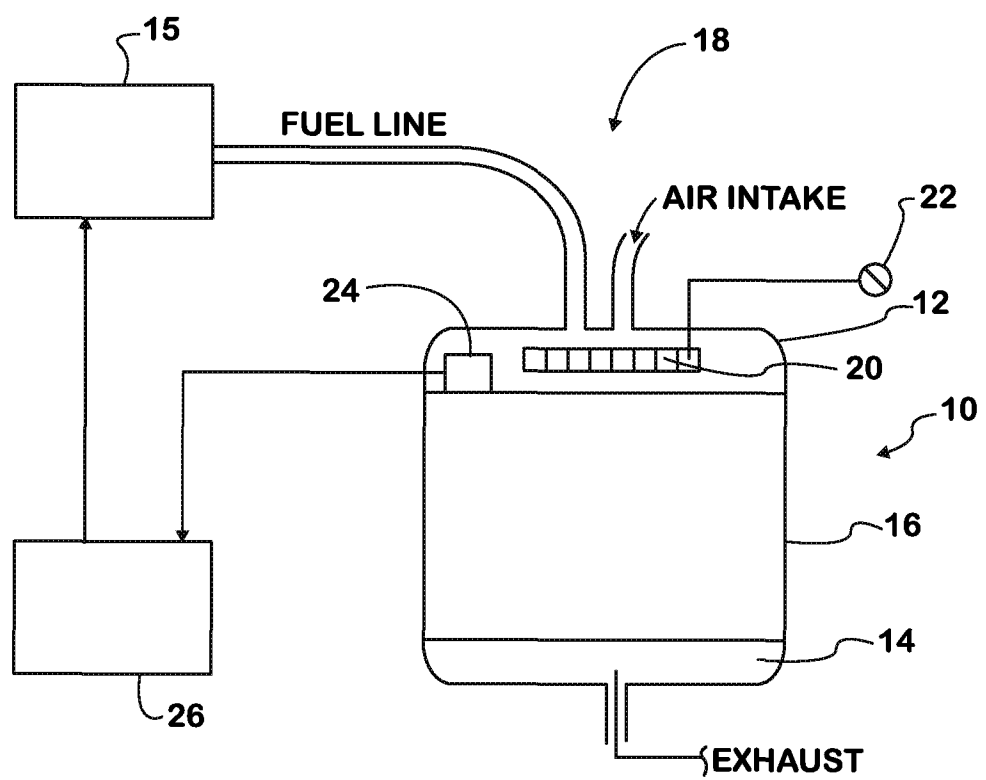
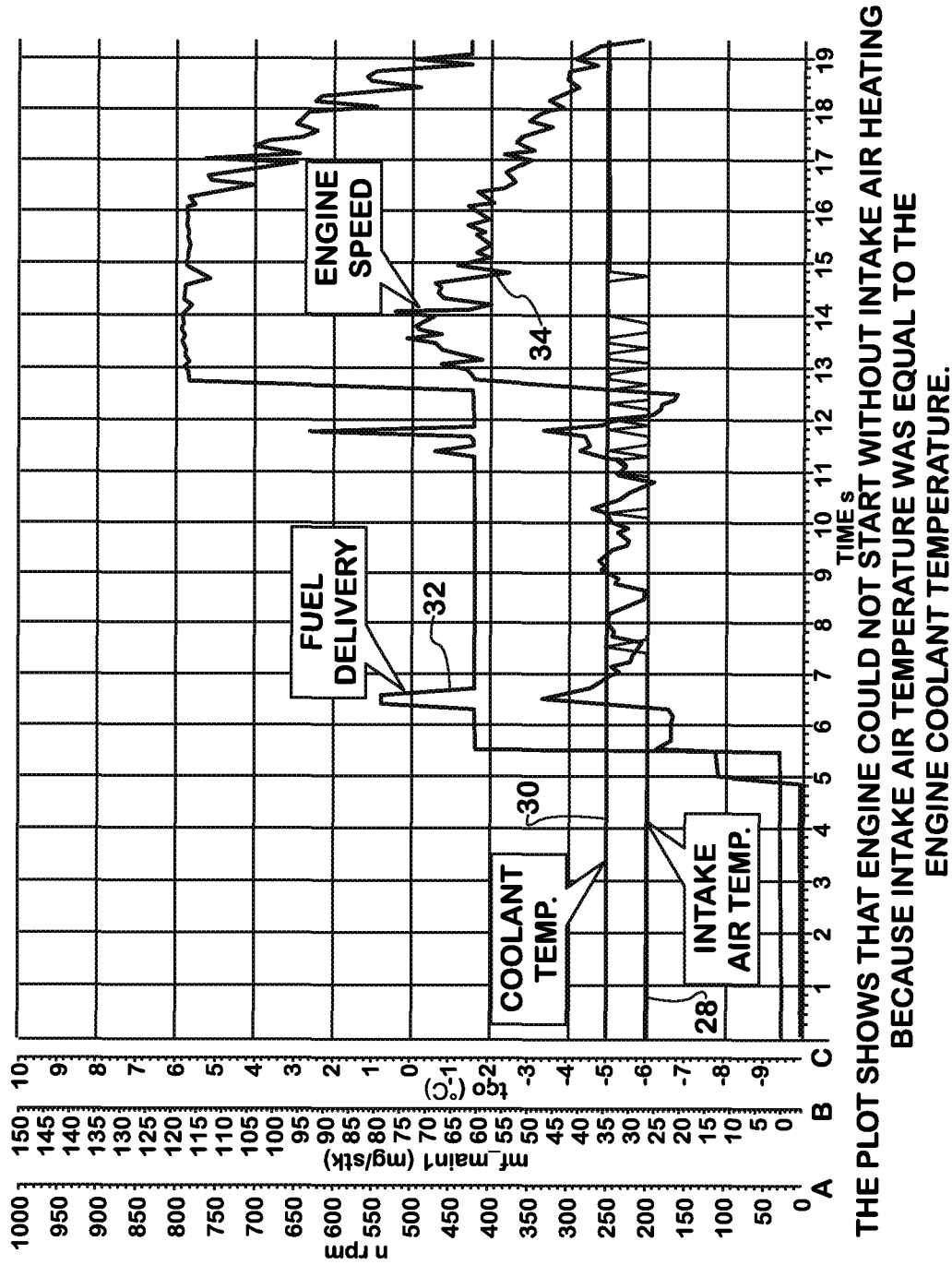


FIG. 1



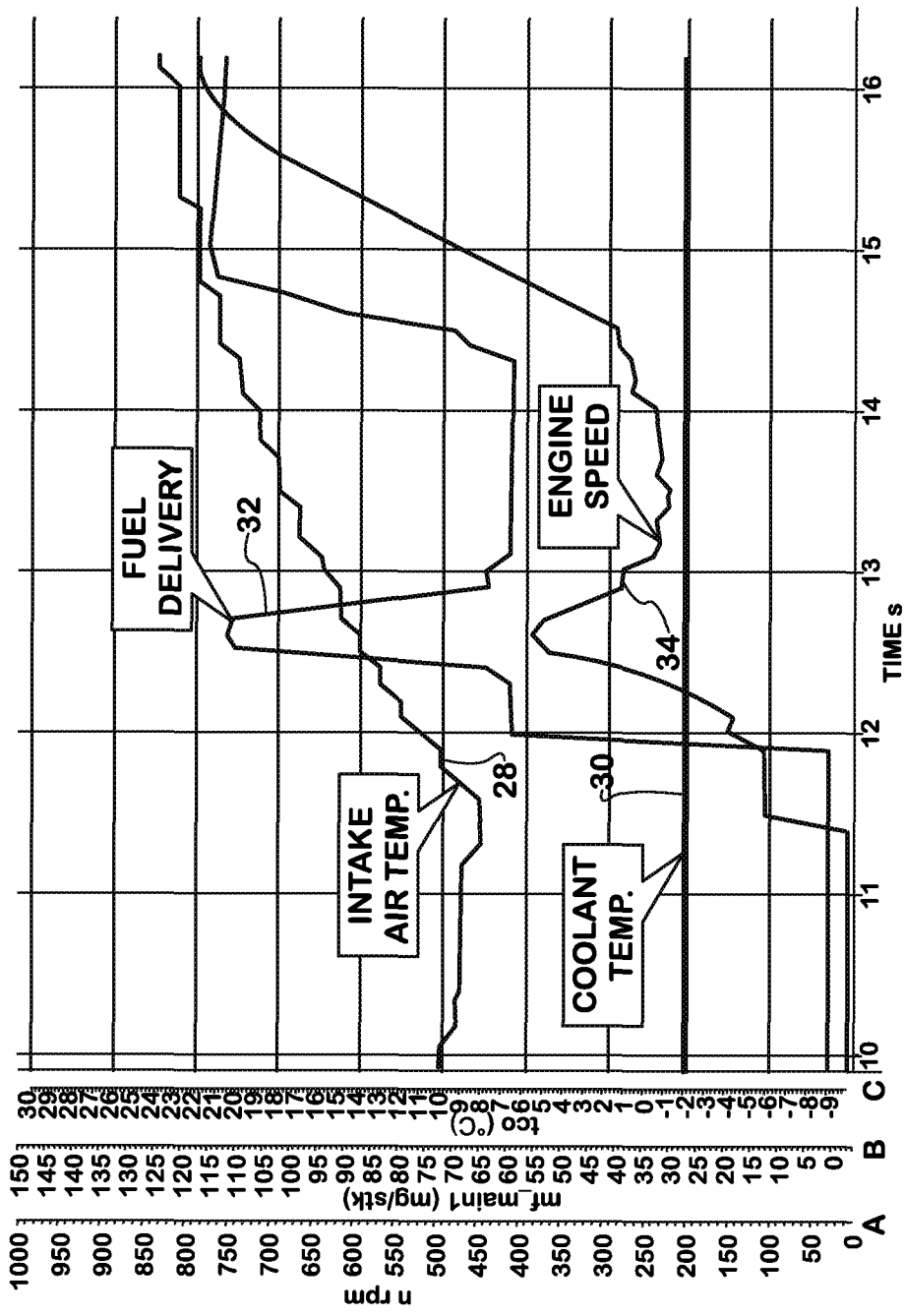


FIG. 3

THE PLOT SHOWS THAT THE ENGINE STARTED WITH THE INTAKE AIR HEATING AND AT THE SAME FUEL DELIVERY AS THE PREVIOUS SLIDE THAT THE INTAKE AIR TEMPERATURE WAS HIGHER THAT THE ENGINE COOLANT TEMPERATURE MEANT USING SOME INTKAE AIR HEATING DEVICE. THE ENGINE SPEED REACHED UP TO 750rpm.

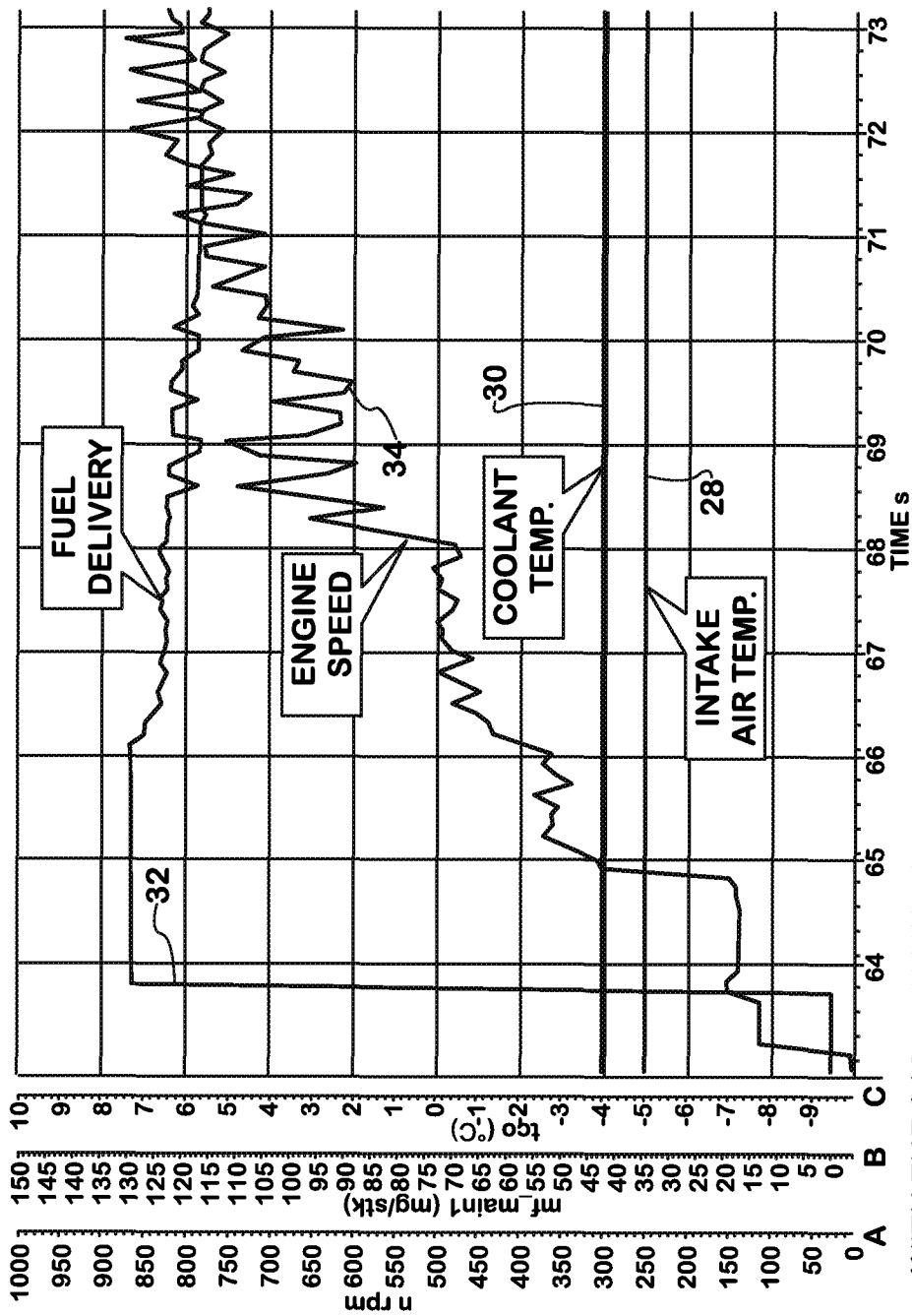


FIG. 4

WITH THE SAME ENGINE AT THE SAME COOLANT AND INTAKE AIR TEMPERATURE AS SLIDE 1, THE ENGINE WAS SUCCESSFULLY STARTED WITH INCREASED FUEL DELIVERY THOUGH THERE WAS STILL NO INTAKE MANIFOLD HEATING.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2011/021827

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - F02M 31/13 (2011.01)

USPC - 123/549

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)

IPC(8) - F02N 19/04, F02M 31/13 (2011.01)

USPC - 123/179.16, 179.18, 179.21, 549, 552, 555, 556; 701/103

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)

PatBase, Google Patent

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4,944,260 A (SHEA et al) 31 July 1990 (31.07.1990) entire document	1, 4, 6-8, 10-13
-----		-----
Y		2, 3, 5, 9, 14
Y	US 2006/0150958 A1 (GILL et al) 13 July 2006 (13.07.2006) entire document	2, 3
Y	US 2004/0016416 A1 (ICHIHARA et al) 29 January 2004 (29.01.2004) entire document	5, 9, 14
A	US 2002/0092492 A1 (OHANIAN et al) 18 July 2002 (18.07.2002) entire document	1-14
A	US 4,465,051 A (HASEGAWA) 14 August 1984 (14.08.1984) entire document	1-14
A	US 5,586,544 A (KITAMURA et al) 24 December 1996 (24.12.1996) entire document	1-14

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

* Special categories of cited documents:

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

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

01 March 2011

Date of mailing of the international search report

14 MAR 2011

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents

P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

Authorized officer:

Blaine R. Copenheaver

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774