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(54) A device to monitor glow plugs in a vehicle

(57) The invention relates to the field of monitoring glow plugs. The device (100) receives a set of engine parameters (104) to control a set of glow plugs (110 to 113). A measuring means (118) measures a set of glow plug parameters. A recording means (120) records selected glow plug parameters and associated engine parameters present at the same time, as history. A life time model computing means (122) continuously analyses the history to compute an aging factor of the glow plugs. The life time model computing means also computes remaining life time of the glow plugs depending upon the specified life time of the glow plugs and the aging factor by computing the ageing factor in dependence of at least two of the a cooling rate, a power density, a corrosion and an erosion. A warning means (124) generates a warning if the remaining life time of the glow plug is less than a pre-defined threshold.

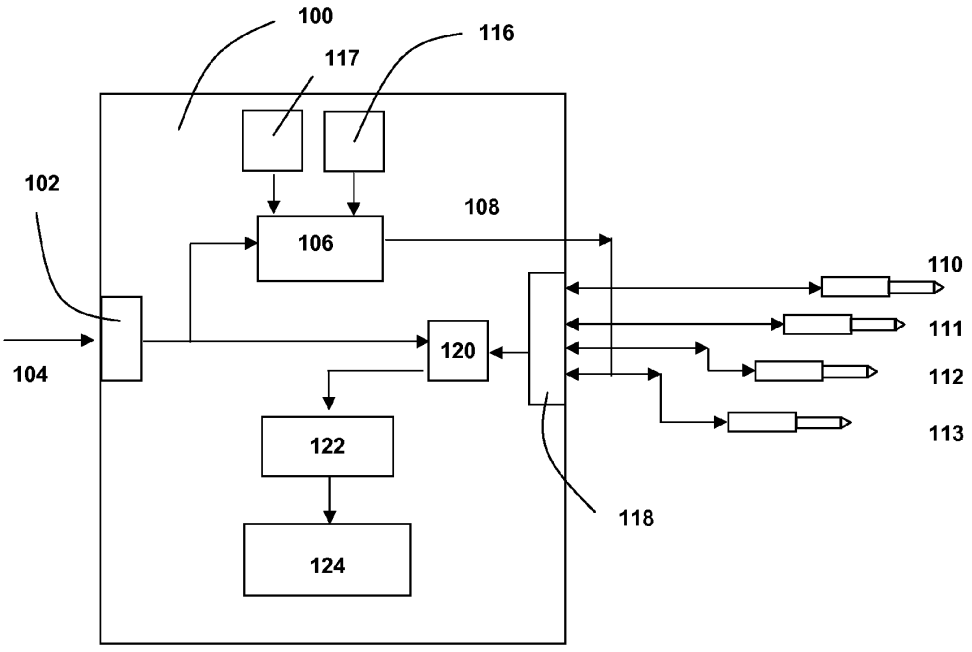

Fig. 1

EP 2 314 863 A1

Description

State of the Art

[0001] The invention relates to a glow plug controller for a combustion engine. The US 2008/0319599 A1 discloses a glow plug controller which detects an underperforming glow plug, based on the reading from the engine speed.

Advantages of the invention

[0002] The device and method according to the independent patent claims have the below mentioned advantages:

The said device proposed in the invention provides information about remaining life time of the glow plugs. This information will help the user to plan in advance the replacing of the glow plugs.

The said device proposed in the invention has a recording means which records the glow plug parameters and engine parameters which can be analysed later to determine the cause of the failures of the glow plugs.

[0003] Further improvements and/or advantages are realised by the features of the dependent patent claims.
[0004] It is possible to analyse the glow plugs based on the recorded engine parameters and the glow plug parameters without having to conduct the actual measurements again. The recorded engine parameters and glow plug parameters are close to the actual working conditions of the engine and provide a possibility for further test and development of the glow plugs and the glow controllers.
[0005] When a glow plug completely fails to operate, it is possible to know the reason why the glow plug failed, by analysing the recorded engine parameters and glow plug parameters.

Brief descriptions of the drawings

[0006] The embodiments of the invention are shown in the drawing and are described in detail in the description.

Figure 1 Shows the schematic of the invention according to a first embodiment

Figure 2 Shows the schematic of the invention according to a second embodi- ment

Figure 3 Shows the schematic of an electronic tester

Description of the embodiments

[0007] Shown in Fig. 1 is a device 100 to monitor at least one glow plug 110 to 113. The said device 100 comprises a receiving means 102 receiving a set of engine parameters 104 and delivering the engine parameters 104 to a control means 106 to generate a set of control signals 108 to control the glow plugs 110 to 113. Further a calibrated MAP 116 and a reference MAP 117 contain various data required by the control means 106 to control the glow plugs 110 to 113. The reference MAP 117 provides the maximum voltage to be applied to the glow plugs based on the engine operating conditions. This is provided by the manufacturer of the glow plugs. The calibrated MAP 116 contains the fine tuned voltage values to be applied for the glow plugs for different engine operating conditions. The calibrated MAP is prepared during the application phase of the engine when the engine is tested along with the glow plugs. A measuring means 118 continuously measures the glow plug parameters.
[0008] The engine parameters comprise at least air mass, air temperature, swirl, oil consumption, Kilometres travelled, pressure of fuel supplied which is referred as rail pressure, and spray lay out. The swirl indicates how the air-fuel mixture in the combustion engine rotates. The spray lay out indicates the position of the glow plugs with relative to the injection streams.
[0009] The glow plug parameters comprise at least voltage V of the glow plugs, current I of the glow plugs, temperature of the glow plugs, material of the glow plugs etc.
[0010] A recording means 120 records a few selected glow plug parameters along with the associated engine parameters which are present at the same time. The data recorded by the recording means is referred as history. A life time model computation means 122 continuously computes an aging factor based on the history and provides information on remaining life time of the glow plugs.
[0011] Each of the glow plugs 110 to 113 have their tips located in separate cylinders of an engine which is not shown. When the glow plugs 110 to 113 are energised, they help in igniting the fuel, especially when the engine is at a lower temperature.
[0012] The number of glow plugs is shown as 4 as an example and the number of glow plugs may vary based on the engine requirements.
[0013] The said device 100 according to the invention comprises all the features of a conventional glow plug controller. In addition the device 100 further comprises the recording means 120 and the LTM (Life Time Model) computing means 122.
[0014] The invention proposes a device and a method to record the history of the glow plugs and also to provide information on the remaining life time of the glow plugs.
[0015] A warning means 124 gets automatically activated whenever a pre-defined condition is encountered. There may be different pre-defined conditions like, for

example, if the remaining life time of a glow plug is less than a predefined threshold etc. The warning means 124 can also be activated by a user at any time when the glow plugs are not currently operational.

[0016] The warning means 124 generates a warning signal when the predefined condition is satisfied. The warning signal may be used to glow one or more warning lamps or may be used to display a message in the instrument cluster of the vehicle.

[0017] The computation of the remaining life time of the glow plugs is explained below:

> The aging factor of a glow plug is computed as a combination of at least two of the parameters from: cooling rate, power density, corrosion, erosion.

[0018] The cooling rate is computed using at least air mass, air temperature and swirl.

[0019] The power density is computed using at least U, I, V where U is the volume of the glow plug bit, I is the current of the glow plug and V is the voltage of the glow plug.

[0020] The corrosion is computed using at least oil consumption, kilometers, glow plug temperature, glow plug material.

[0021] The erosion is computed using at least pressure of the fuel which is referred as rail pressure, spray layout, glow plug material.

[0022] The remaining life time of a glow plug is computed as f (specified life time of the glow plug, aging factor of the glow plug)

[0023] Each of the parameters used in the above computations are either part of the engine parameters or the glow plug parameters or they are pre-stored in the said device 100.

[0024] When the remaining life time of a glow plug is below a set threshold, the said warning means generates a warning to the user so that the vehicle can be taken to a service station for replacing the glow plugs.

[0025] By knowing the remaining life time of the glow plugs, the replacement of the glow plugs can be planned in advance.

[0026] As the history of the glow plugs is recorded, it is possible to test the vehicle based on the history without having to conduct the actual measurements once again. The analysis of the history will indicate probable cause of the abnormality of the glow plugs. The abnormality of the glow plugs may be complete failure of the glow plugs to operate or the glow plugs operating beyond their set thresholds.

[0027] The history is close to the actual working conditions of the engine and the glow plugs; hence they provide a possibility for further test and development of the glow plugs and the glow plug controllers.

[0028] Based on the history, it is possible to compute the remaining life time of the glow plugs and to predict when the glow plugs need to be replaced. The engine control unit or the said device 100 in the vehicle can keep monitoring for the remaining life time of the glow plugs and can generate warnings to the user sufficiently in advance for replacing the glow plugs. A warning is generated if the computed life time of any of the glow plugs is below a set threshold. The warning could be an audio signal or a visual indicator.

[0029] By continuously updating the history, a life time model of the glow plugs can be computed. The life time model of the glow plugs can be used to further study the durability and the aging of the glow plugs. Because of the aging, the temperature generated at the glow plugs may decrease over a period of time for the same voltage applied. The life time model so computed can be used to know the variations in the temperature because of the aging and to generate an appropriate compensation for the aging. The compensation may be in the form of adding a positive offset to the voltage of the glow plugs to generate a specific temperature.

[0030] Also if the remaining life time of a glow plug is below a set threshold, the said device 100 or the engine controller can adapt the control means 106 to soft modes in which the glow plugs are operated at a lower load, for example when the push up is required from low temperature to very high temperature, the temperature is increased gradually rather than increasing rapidly.

[0031] Also if the remaining life time of a glow plug is below a set threshold, some of the modes of the engine or the glow plugs can be de-activated, for example the re-generation mode of the engine where extra temperature is required in the exhaust. These modes need additional operational time from the glow plugs which can be avoided if the glow plugs' life time is below a set threshold. This is like providing a limp home feature for the glow plugs where the glow plugs operate with limited features. In other words the glow plugs are operated in modes which prolong the remaining life time of the glow plugs.

[0032] The above two features are to ensure that whenever the remaining life time of the glow plugs is below a set threshold, the life of the glow plug is extended to maximum possible period to enable the user to take the vehicle to the service station to replace the glow plugs.

[0033] Based on the size of the memory available, a multiple sets of history can be stored. Whenever the memory is full, the oldest set of history can be overwritten.

[0034] The embodiment shown in Fig. 1 shows the device 100 receiving the engine parameters, analysing the engine parameters and generating the control signals to the glow plugs and also monitoring the glow plugs. Here the device includes a microcontroller and the associated components like memory etc.

[0035] In an alternative embodiment, the function of the device 100 can be included in the engine controller.

[0036] In another embodiment, the device 100 and the engine controller may share part of the recording functionality or share part of the monitoring of the glow plugs.

[0037] In another embodiment shown in Fig. 2, the device does not include the processing means 124 and the

LTM computing means 122. The embodiment in Fig. 2 is similar to Fig. 1 and describes the same elements with the same functionalities as in Fig. 1. The device 200 has an interface means 202 which establishes a communication with an external device on detection of a pre-defined event. The pre-defined event may be a time out or detection of an external device connected to the interface means 202. After establishing the communication with an external device, the interface means 202 reads the history and sends the same through an output port to an external device for processing.

[0038] Shown in fig. 3 is a diagnostic tester 300 which receives the history from the device 200 shown in fig. 2. The diagnostic tester may be a device used in a work shop to test the vehicles. When the diagnostic tester is connected to the device 200, both the devices establish communication using pre-defined hand shake messages through the interface means 302. Once the communication is established, the diagnostic tester 300 receives the history using a pre-defined protocol.

[0039] The processing means 304 is similar to the processing means 124. The processing means 304 provides information regarding the remaining life time of the glow plugs based on the analysis of the history.

Claims

1. A device (100) to monitor at least one glow plug (110, 111, 112 and 113), the said device (100) comprising a receiving means (102) to receive at least one engine parameter (104), a measuring means (118) to measure at least one glow plug parameter, the said device comprising a recording means (120) adapted to record engine parameters and glow plug parameters, the said device (100) **characterised by**

   - a Life Time Model (LTM) computing means (122) adapted to compute an aging factor of the glow plugs in dependence of at least two of the parameters from : a cooling rate, a power density, a corrosion and an erosion; wherein the cooling rate is computed using at least air mass, air temperature, swirl; the power density is computed using at least U, I, V where U is volume of the glow plug bit; the corrosion is computed using at least oil consumption, kilometres travelled, glow plug temperature, glow plug material; erosion is computed using rail pressure, spray layout, material of glow plugs.
   - the said LTM computing means (122) further adapted to compute remaining life time of the glow plugs as a function of a specified life time of the glow plugs and the aging factor of the glow plugs .

2. A device (100) according to claim 1 wherein the engine parameters and glow plug parameters are analysed to determine the cause of the failure of the glow plugs

3. A device (100) according to claim 1 wherein a warning means (124) gives an indication to the user about the aging of the glow plugs.

4. A device (100) according to claim 1 wherein a control means (106) operates the glow plugs at a lower load when the remaining life time of a glow plug is below a predetermined threshold.

5. A device (100) according to claim 1 wherein a control means 106 operates the glow plugs in a mode to prolong the remaining lifetime of the glow plugs, when the remaining life time of a glow plug is below the threshold.

6. A diagnostic tester 300 comprising an interface 302 adapted to receive history from a glow plug monitoring device, the said diagnostic tester **characterised by** a Life Time Model (LTM) computation means (304) adapted to continuously compute an aging factor of the glow plugs in dependence of the said history.

7. A method to predict remaining life time of a glow plug, the method comprising the steps:

   - reading the engine parameters, measuring the glow plug parameters
   - recording few of the selected glow plug parameters along with the associated engine parameters as history
   - computing an aging factor in dependence of the history
   - computing a remaining life time of the glow plug as a function of specified life time and aging factor

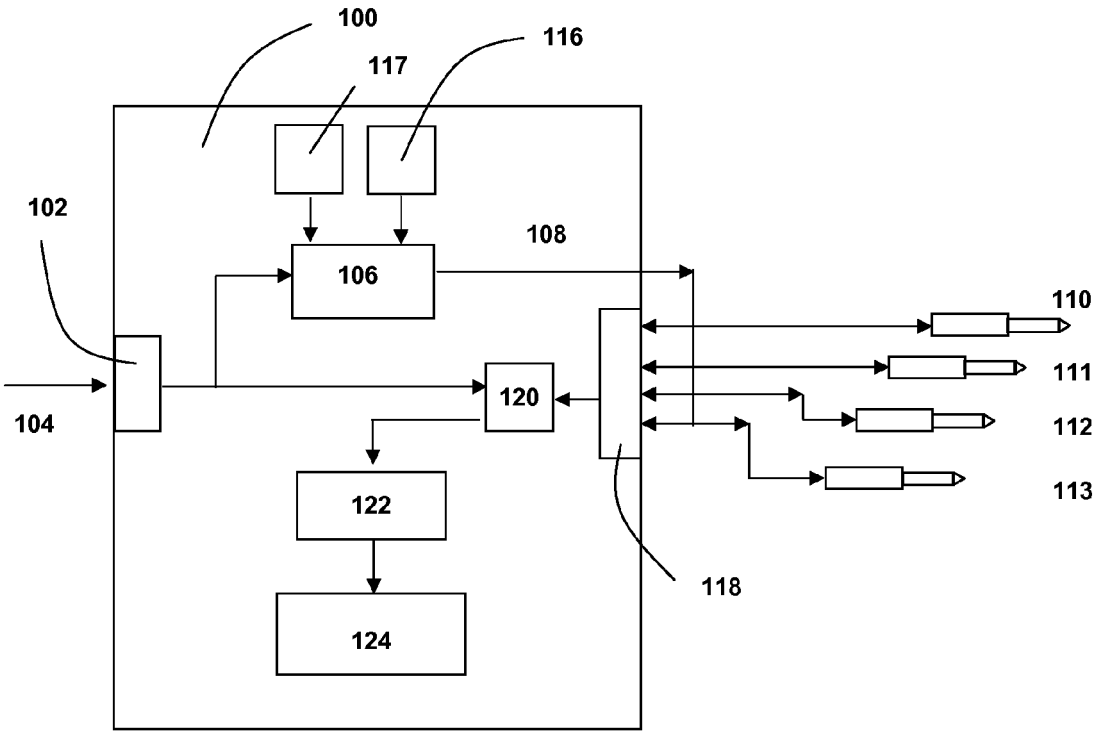

Fig. 1

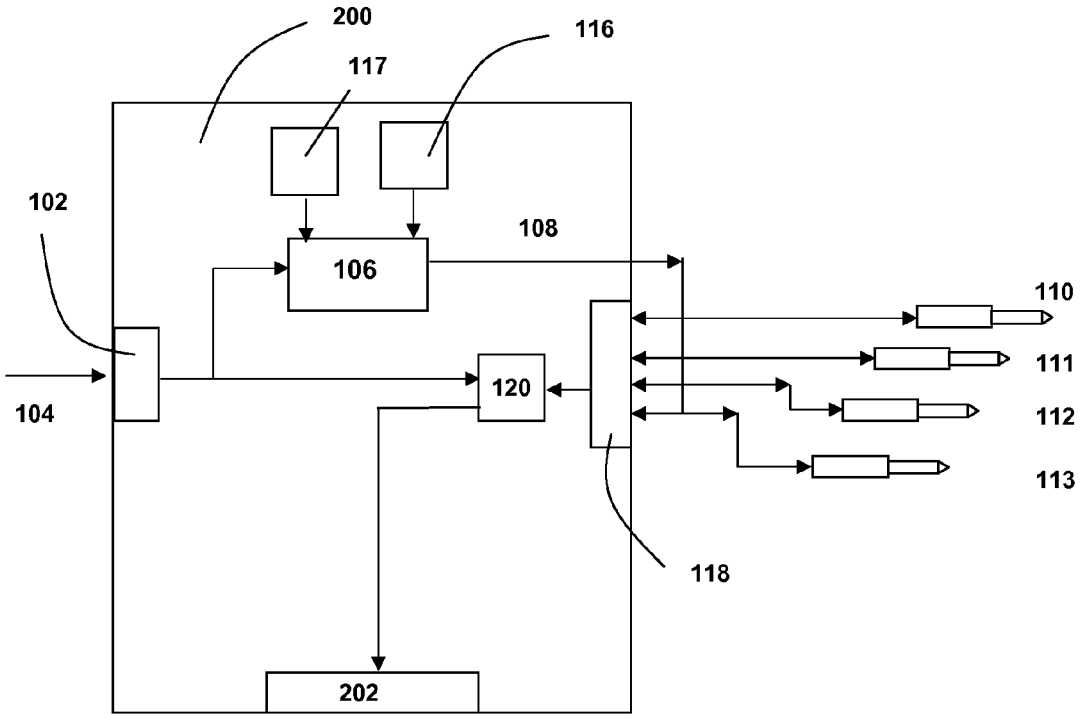
200
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Fig. 2

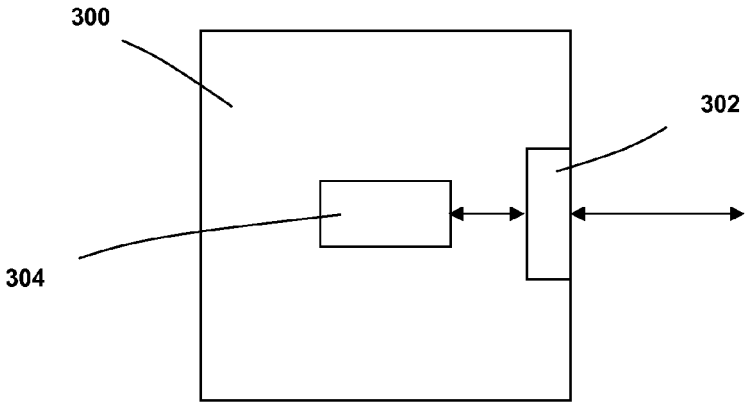
300
302
304

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 09 17 3392

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Place of search	Date of completion of the search	Examiner
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