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(54) **INTERNAL COMBUSTION ENGINE COMPRISING A COOLANT CIRCUIT AND TERRESTRIAL VEHICLE COMPRISING SAID INTERNAL COMBUSTION ENGINE**

(57) Internal combustion engine (E) comprising a coolant circuit (C) wherein coolant is recirculated through a pump (P) and wherein a PH sensor (PHS) is arranged in such a way to sense PH thereof and to signal a deterioration of the coolant requiring the replacement thereof with fresh one on the basis of said PH sensed.

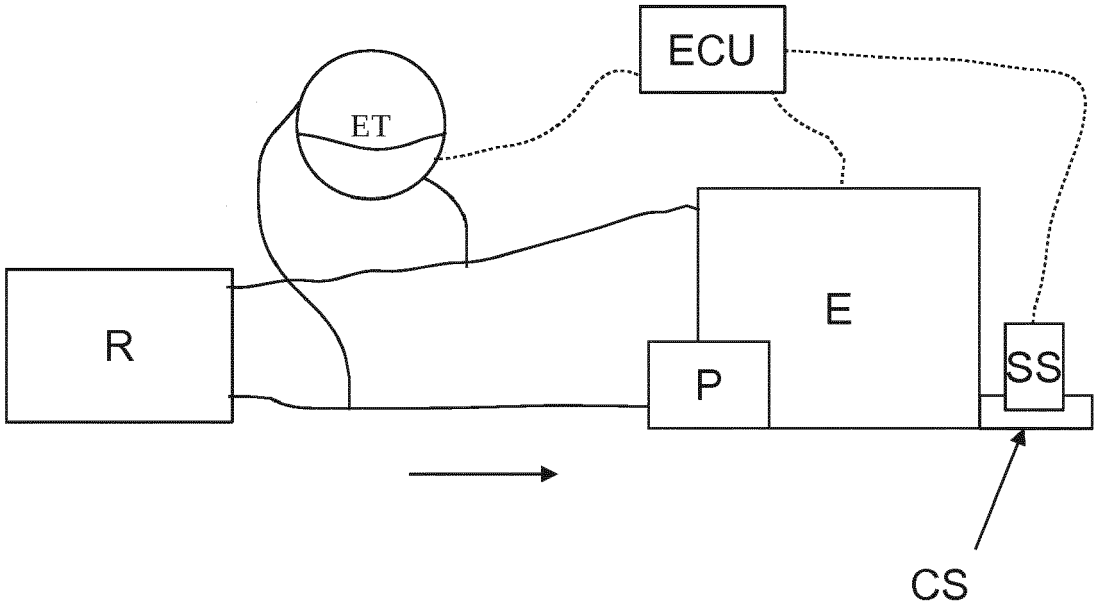

Fig. 1

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Description

Field of the invention

[0001] The present invention relates to an internal combustion engine comprising a coolant circuit and land vehicle, preferably industrial vehicles, comprising said internal combustion engine.

Description of the prior art

[0002] The quality of coolant of the internal combustion engines is important for save the integrity of the combustion engine itself.

[0003] One-third of heat energy produced by an internal combustion engine is taken away by the coolant. This heat removed by the coolant provides a balance in the overall removal of engine heat that is critical in ensuring that the engine operates properly.

[0004] Glycol is mixed to water to provide freeze protection. The addition of glycol slightly reduces the heat transfer of the water, but in most climates and applications, freeze protection is critical.

[0005] In general, coolants degrade over time as the ethylene glycol breaks down into primarily glycolic and formic acids. Degradation occurs more quickly in engines operating at higher temperatures or those that allow more air into cooling systems.

[0006] However, it is not possible to predict the usage of each specific engine, due to the specific mission to which each industrial vehicle is used, thus an average replacing interval is recommended by the manufacturers.

Summary of the invention

[0007] The main object of the present invention is to customize the time interval for replacing coolant for each internal combustion engine.

[0008] According to the present invention, the internal combustion engine is provided with a coolant circuit where coolant is recirculated through a pump. According to the invention the coolant circuit comprises a PH sensor arranged in such a way to be immersed into the coolant in order to sense its PH. It should be understood that the PH sensor is stably associated to the coolant circuit.

[0009] The PH sensor is operatively connected to elaborating means suitable to manage an electric signal produced by said PH sensor and to calculate a PH of coolant and to signal a deterioration of the coolant requiring the replacement thereof with fresh one on the basis of said PH.

[0010] Preferably, said signaling is carried out when such electric signal indicates that PH is under a predetermined threshold, more preferably when PH is **for example** under 7. According to a preferred embodiment of the invention, when the pH falls under a predetermined threshold under value 7, the cranking of the internal combustion engine is inhibited.

[0011] According to a preferred embodiment of the invention, the coolant circuit comprises an expansion tank and said PH sensor is coupled with said expansion tank so as to have at least its own sensing portion immersed into the coolant. According to a preferred embodiment of the invention, said elaborating means are arranged to calculate a PH value of the coolant when the coolant temperature is under a predetermined upper threshold and preferably within a predetermined temperature range defined by said upper threshold and a lower threshold.

[0012] According to a further embodiment of the invention that can be combined with any of the previous ones, said elaborating means are arranged to measure a PH value of the coolant when the combustion engine is switched off and the combustion engine is stationary. When a land industrial vehicle implements said internal combustion engine the combustion engine is considered to be stationary when the vehicle, as a whole, is stationary.

[0013] These and further objects are achieved by means of the attached claims, which describe preferred embodiments of the invention, forming an integral part of the present description.

Brief description of the drawings

[0014] The invention will become fully clear from the following detailed description, given by way of a mere exemplifying and non limiting example, to be read with reference to the attached drawing figures, wherein:

- Fig. 1 shows an internal combustion engine provided with a coolant circuit;
- Fig. 2 shows a detail of the circuit of figure 1 ;
- Fig. 3 shows a land industrial vehicle comprising the combustion engine of figure 1.

[0015] The same reference numerals and letters in the figures designate the same or functionally equivalent parts. According to the present invention, the term "second element" does not imply the presence of a "first element", first, second, etc.. are used only for improving the clarity of the description and they should not be interpreted in a limiting way.

[0016] Many changes, modifications, variations and other uses and applications of the subject invention will become apparent to those skilled in the art after considering the specification and the accompanying drawings and claims which disclose preferred embodiments thereof.

Detailed description of the preferred embodiments

[0017] According to certain practices the coolant is tested on an annual basis if it is intended to operate the system for several years between coolant changes, and particularly where the coolant is used in severe applica-

tions.

[0018] In order to determine the coolant efficiency, one test ensures the PH is still above 7.0. Some coolant technologies can protect as low as PH 6.5, however, it is not good practice to allow a coolant to operate below a PH of, for example, 7.0.

[0019] However, it is known that certain additives let the coolant to change its acidity in a short time period.

[0020] Also a coolant based on water and ethylene glycol suffers such a problem.

[0021] According to the present invention, a PH sensor PHS is coupled with the coolant circuit C in order to monitor the coolant acidity constantly, namely according to relatively short time intervals.

[0022] Advantageously, each measurement does not requires the depressurization of the coolant circuit in order to sample the coolant.

[0023] According to figure 1, an internal combustion engine E, preferably a Diesel or a spark engine is provided with a coolant circuit where coolant is recirculated by a pump P in order to pass through an external radiator R. According to the invention the coolant circuit comprises a PH sensor arranged in such a way to sense its acidity.

[0024] The PH sensor is operationally connected to elaborating means ECU suitable to manage an electric signal produced by said PH sensor and to calculate a PH of coolant and to signal a deterioration of the coolant requiring the replacement thereof with fresh one on the basis of said PH. Preferably, said signaling is carried out when such electric signal indicates that PH is under a predetermined threshold, for example, 7.

[0025] According to a preferred embodiment of the invention, the coolant circuit comprises an expansion tank ET, see figures 1 and 2, and said PH sensor PHS is coupled with said expansion tank so as to have at least its own sensing portion immersed into the coolant.

[0026] According to a preferred embodiment of the invention, said elaborating means ECU are arranged to calculate a PH value of the coolant when the coolant temperature is under a predetermined upper threshold and preferably within a predetermined temperature range defined by said upper threshold and a lower threshold.

[0027] Usually a temperature sensor TS is already associated to the cooling circuit for different purposes e.g. to adjust the fuel injection. According to this preferred embodiment of the invention, the temperature sensed by said temperature sensor, is also used in order to enable the PH calculation.

[0028] In other words, the pH measurement is carried out only when the coolant temperature falls within a predetermined temperature interval.

[0029] According to a further embodiment of the invention that can be combined with any of the previous ones, said elaborating means ECU are arranged to measure a PH value of the coolant when the combustion engine is switched off, preferably the ignition is off and the combustion engine is stationary. Usually, the internal combustion engines are provided with an engine speed sensor SS associated to the crankshaft CS of combustion engine. Thus, according to this preferred embodiment of the invention, the speed sensed by said speed sensor SS, is also used in order to enable the PH calculation.

[0030] When a land industrial vehicle implements said internal combustion engine, the combustion engine is considered to be stationary when the vehicle, as a whole, is stationary, thus also the ABS sensor can be used in order to determine if the vehicle is stationary.

[0031] Thanks to the present invention, the coolant replacement is customized according to the usage of the engine and, in general, the land vehicle comprising the internal combustion engine. In this way, the maintenance of the combustion engine is more adherent to the real conditions of the coolant.

[0032] Preferably, in case the pH fall under a predetermined threshold, the engine start in inhibited, because it indicates a strong contamination of the coolant that could lead to the irreversible damage of the internal combustion engine.

[0033] This invention can be implemented advantageously in a computer program comprising program code means for performing one or more steps of such method, when such program is run on a computer. For this reason, the patent shall also cover such computer program and the computer-readable medium that comprises a recorded message, such computer-readable medium comprising the program code means for performing one or more steps of such method, when such program is run on a computer.

[0034] According to a preferred embodiment of the invention, the PH sensor senses the PH of the coolant and elaborating means signal, for example through a lamp in the vehicle instrument panel, a deterioration of the coolant requiring its replacement with fresh one. The calculation of the PH, or equivalently the signaling, can be subordinated to other conditions such as the coolant temperature, the operating condition of the internal combustion engine and its stationary as described above.

[0035] Preferably, the elaborating means are also suitable to construe a linear regression on the PH values sensed/calculated in order to estimate the remaining time or range before the coolant deterioration and to show, through a display, for example in the instrument pane, such time (in terms of days or months) or range (in terms of mileage) remaining before said deterioration.

[0036] It should be understood that said elaborating means can coincide with the engine control unit (ECU) or other electronic control units usually implemented to monitor and control the combustion engine and preferably also its After Treatment System (ATS).

[0037] It should be understood that all the single features and/or embodiments can be combined between each other. In addition, the features disclosed in the prior art background are introduced only in order to better understand the invention and not as a declaration about the

existence of known prior art. Therefore, also the features described in the prior art background can be considered in combination with those mentioned in each embodiment of the detailed description.

[0038] Further implementation details will not be described, as the man skilled in the art is able to carry out the invention starting from the teaching of the above description.

Claims

1. Internal combustion engine (E) comprising a coolant circuit (C) wherein coolant is recirculated through a pump (P) and wherein a PH sensor (PHS) is arranged in such a way to sense PH thereof and to signal a deterioration of the coolant requiring a replacement thereof with fresh one on the basis of said PH sensed.

2. Engine according to claim 1, wherein said signaling is carried out when such electric signal indicates that PH is under a predetermined threshold.

3. Engine according to any one of previous claims 1 - 2, wherein said PH sensor is operationally connected with a control unit, for example the engine control unit (ECU), arranged to calculate said PH value of the coolant, and configured to carry out said calculation when the coolant temperature is under a predetermined upper threshold.

4. Engine according to any one of previous claims 1 - 3, wherein said PH sensor is operationally connected with a control unit, for example the engine control unit (ECU), arranged to calculate said PH value of the coolant, and configured to carry out said calculation when the combustion engine is switched off.

5. Engine according to any one of previous claims 1 - 4, wherein said PH sensor is operationally connected with a control unit, for example the engine control unit (ECU), arranged to calculate said PH value of the coolant, and configured to carry out said calculation when the ignition is off and stationary.

6. Engine according to claim 3, further comprising a temperature sensor (TS) associated with said coolant circuit and/or a speed sensor (SS) associated with a crankshaft (CS) of said internal combustion engine.

7. Engine according to any one of the previous claims 1 - 6, wherein said coolant circuit further comprises an expansion tank (ET) and wherein said PH sensor PHS is coupled with said expansion tank so as to have at least its own sensing portion immersed into the coolant.

8. Engine according to any one of previous claims 3 - 7, wherein said control unit is programmed to inhibit the engine start when said pH value of the coolant is below a predetermined value.

9. Method to determine a coolant replacement of an internal combustion engine according to any of the previous claims 1

   - 8, comprising the step to calculate a PH of said coolant when the coolant temperature is under a predetermined threshold or within a temperature range and/or when the internal combustion engine is switched off and/or the ignition is off and/or when the internal combustion engine is stationary.

10. Method according to claim 9, further comprising the step of acquiring PH values and to construe a linear regression on said PH values in order to estimate a remaining time or range before the coolant deterioration and a consequent step of showing, through a display such time or range remaining before said deterioration. 8.Vehicle (LV), in particular a land industrial vehicle, comprising the internal combustion engine (E) according to any one of claims 1 - 8.

11. Computer program comprising computer program code means adapted to perform all the steps of claim 9 or 10 when said program is run on a computer.

12. A computer readable medium having a program recorded thereon, said computer readable medium comprising computer program code means adapted to perform all the steps of claim 9 or 10, when said program is run on a computer.

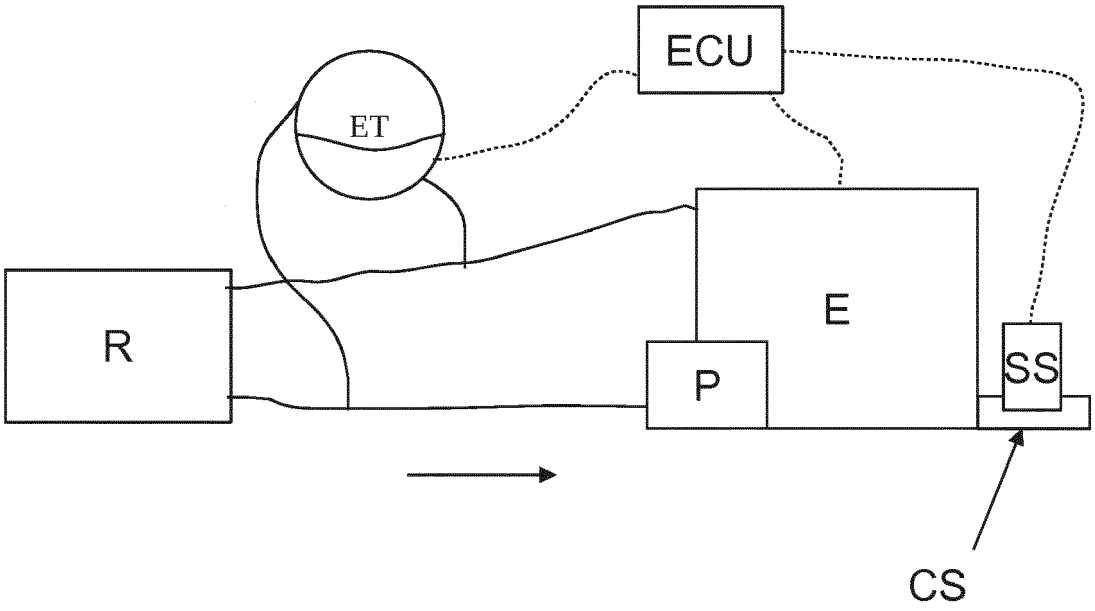

Fig. 1

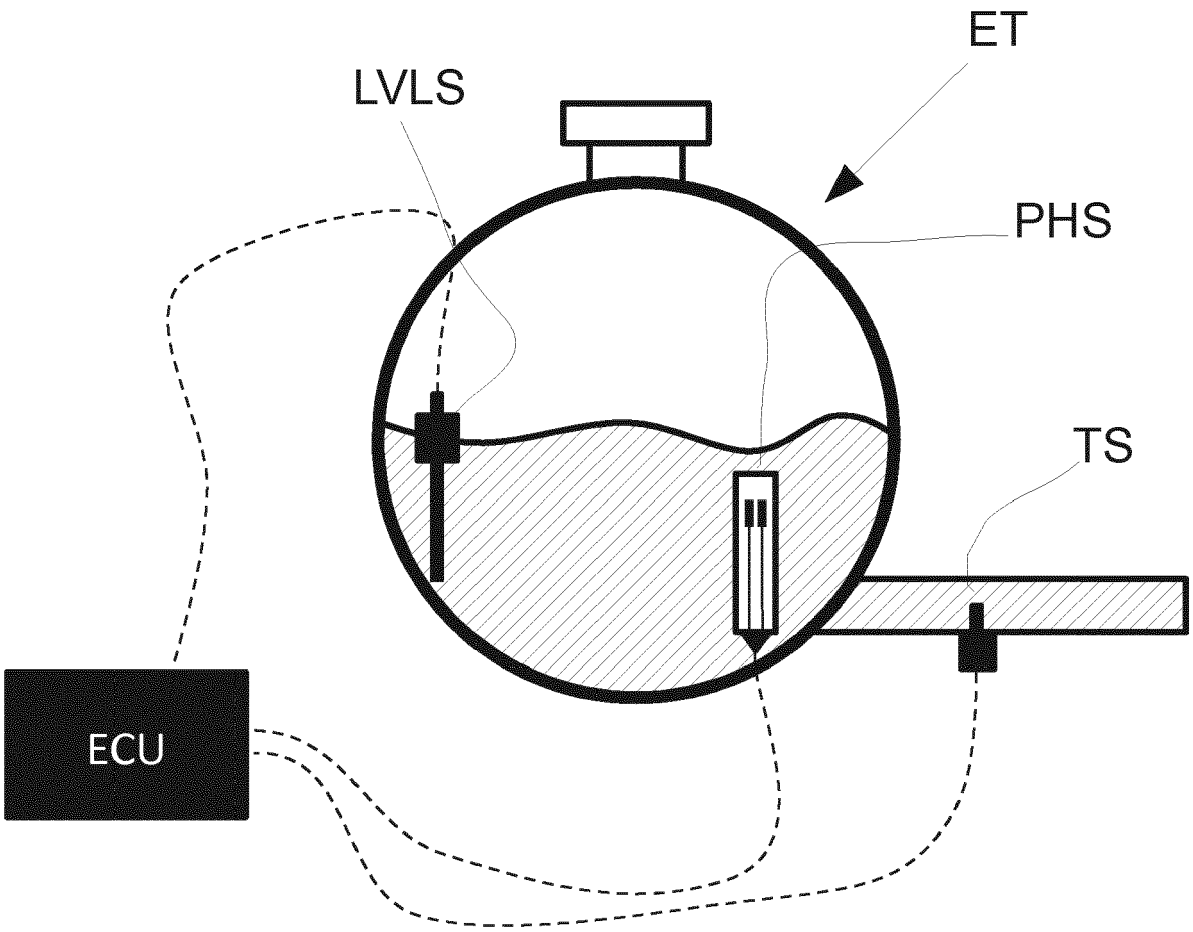

Fig. 2

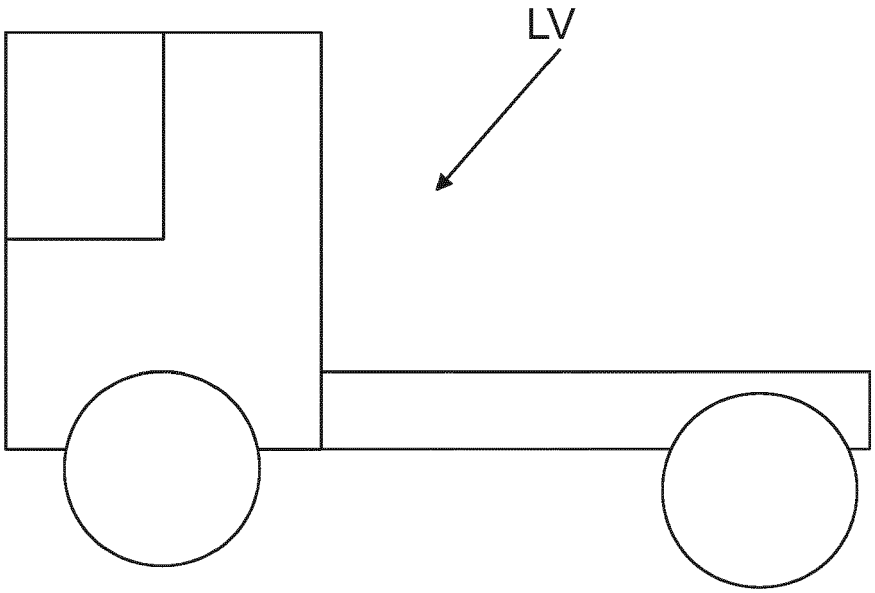

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 17 19 0664

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y A	US 2005/034510 A1 (HAN CHARLIE BUN [US]) 17 February 2005 (2005-02-17) * paragraphs [0002], [0007], [0008], [0911], [0012], [0013]; figure 1 *	1,2,11 7 3-6,9	INV. F01P11/14
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A	US 2003/173970 A1 (HORIE KAZUYUKI [JP] ET AL) 18 September 2003 (2003-09-18) * paragraphs [0009] - [0013], [0036], [0053]; figures 1,2 *	1-13	
A	US 5 094 757 A (LIGHT STEVEN T [US]) 10 March 1992 (1992-03-10) * column 1, line 30 - column 2, line 24; figure 1 * * column 3, lines 31-48 *	1-13	
A	US 2014/303831 A1 (NAM GI YOUNG [KR] ET AL) 9 October 2014 (2014-10-09) * paragraphs [0007], [0009], [0010], [0020] - [0023], [0026]; figures 1,3,4 *	1-13	TECHNICAL FIELDS SEARCHED (IPC) F01P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 September 2017	Luta, Dragos

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82