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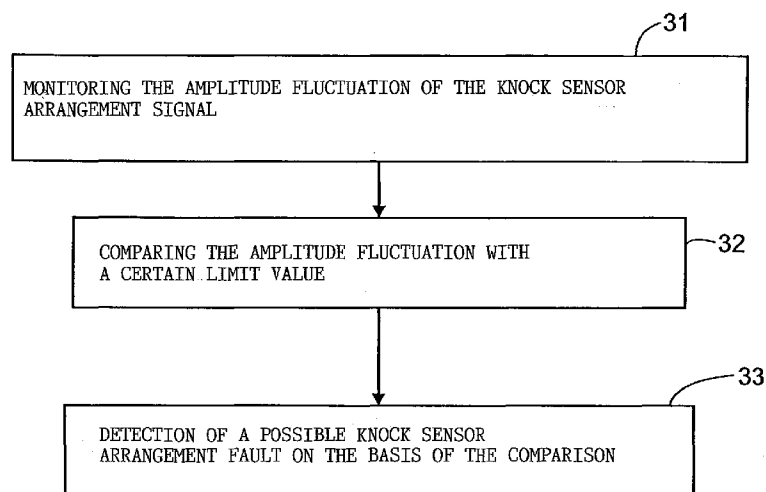


FIG. 3

(57) Abstract: The method according to the invention comprises steps for recognizing a fault in a system used in connection with a piston engine. A monitoring step (31) of the method is carried out for monitoring the amplitude fluctuation of the signal of the knock sensor arrangement. The second step (32) is made for comparing the amplitude of the signal and a certain limit value and the third step (33) is for detecting any faults in the knock sensor arrangement on the basis of the said comparison. The apparatus according to the invention is arranged to carry out the steps of the inventive method.

AN INDICATOR ARRANGEMENT

Field of invention

The present invention relates to indicators used in piston-operated internal combustion engines, such as diesel engines or gas engines. The invention especially relates to knock indicators.

Background art

Many kinds of different indicators are used in piston-operated internal combustion engines for observing different units and states in engines. The temperature of a cylinder can be measured; the fuel flow to be supplied can be monitored; the engine running speed can be measured and so on. The knocking occurring in a cylinder can also be monitored.

A cylinder knocks when the air-fuel mixture introduced therein is ignited in an undesired manner. Typically knocking occurs when the air-fuel mixture or the fuel used separately for ignition is ignited too early. Knocking stresses the engine and can damage the engine. Knock control is used to avoid engine knock by controlling the ignition timing and/or fuel injection for each cylinder. Knock control can reduce the engine load. The last alternative is to even turn the engine off if deemed necessary. It is also possible to recycle exhaust gas back to the engine, whereby the so-called knock margin is increased. Knock margin means the difference between the units of the operating state of the cylinder and the state causing the knock. The larger the margin is, the smaller the probability of the cylinder turning into the knock-causing state.

It is nowadays common to measure the knock by means of an acceleration sensor from the cylinder head, cylinder sleeve or the engine block. The acceleration sensor is typically a piezoresistive crystal. The signal emitted by the sensor is measured at

the correct moment (i.e. when the crank rotation angle is suitable) at the time knock is most likely to occur. Noise and excess frequencies are filtered from the signal. The processed signal is compared with the reference value, whereby it is possible to deduce whether the cylinder is in a knock state.

- 5 If the knock-indicating sensor and the cables connected thereto are not damaged, knocking can be reliably detected. However, if the sensor or the cables connected thereto are damaged, the signal provided by the sensor can be incorrect. The engine can be incorrectly controlled on the basis of the incorrect signal whereby there is a great risk of damaging the engine. The engine causes vibration that can in the long
- 10 run damage the sensor, the cables connected thereto or the connections of the cable.

Brief description of the invention

- 15 An aim of the present invention is to reduce the above-mentioned disadvantages. The aim is achieved as described in the main claim. The dependent claims describe the various embodiments of the invention.

- 20 The method according to the invention comprises steps for detecting a fault in a system used in connection with a piston engine. A monitoring step of the method is carried out for monitoring the amplitude fluctuation of the signal of the knock sensor arrangement. The second step is for comparing the amplitude of the signal and a certain limit value and the third step is for detecting any faults in the knock sensor arrangements on the basis of the said comparison. The apparatus according to the invention is arranged to carry out the steps of the inventive method.

25 List of figures

In the following the invention is described in more detail by reference to the figures in the drawing, in which

- Figure 1 illustrates an example of the fault detecting apparatus according to the invention,
- Figure 2 illustrates the detection of the fault from the monitored signal, and
- 5 Figure 3 is a block diagram of the method according to the invention.

Description of the invention

Figure 1 illustrates an example of the apparatus according to the invention and the way it is connected to a certain system of the internal combustion engine. In the example of figure 1 a knock detection sensor 1 (usually an acceleration sensor) is connected via filtering means 2 to a measurement apparatus 3. In the measurement apparatus the filtered signal of the sensor 1 can be used for detecting whether the cylinder knocks. The filtering apparatus is simply shown as a capacitor, but it will be obvious to one skilled in the art to carry the filtering means out as appropriate for the purpose. In practice the sensor 1 is connected via the filter to the measurement apparatus with a cable 5, the length of which can be many metres. Both the sensor 1 and the cable 5 can be damaged by the vibration of the engine and other external factors.

In the example of figure 1 for detecting a fault in the knock sensor arrangement the measurement apparatus is provided with a fault detection apparatus 4 according to the invention. The fault detection apparatus can also be placed outside the measurement apparatus for monitoring the signal provided by the sensor 1. The fault detection apparatus is arranged to monitor the amplitude fluctuation of the signal of the knock sensor arrangement, to compare the amplitude fluctuation with a certain limit value and to detect any fault in the knock sensor arrangement on the basis of the comparison. The fault apparatus 4 can be carried out with software as a computer

program, as an ASIC circuit (Application Specific Integrated Circuit) or as a more traditional circuit.

Figure 2 illustrates detection of a fault. Usually, the signal of the knock sensor fluctuates in a certain way. This fluctuation can be followed by, for example, calculating the variance from the sensor signal. The fluctuation of the signal can also be observed by other means than variance. In figure 2 signal 6 thus describes the amplitude fluctuation of the knock sensor signal and the amplitude fluctuation of the signal can be, for example, the variance of the signal. When a fault occurs in the knock sensor arrangement (such as the sensor 1, cable 5 or the connections of the cable being damaged), the amplitude of the signal changes, a normally high fluctuation of signal amplitude is considerably reduced as shown in figure 2. The monitoring of the fluctuation of the knock sensor signal is preferably made from a filtered knock sensor signal so that noise and other disturbances do not have an effect on the monitoring of the amplitude fluctuation.

When the fault detection apparatus 4 notices a change in the knock signal fluctuation 6, with the level of fluctuation dropping below a certain limit value 7, the fault detection apparatus performs fault detection. The apparatus thus compares the fluctuation of the signal amplitude to the limit value 7 and when the fluctuation of the signal amplitude is less than the limit value, the apparatus performs a fault detection operation. An example of fault detection operation is changing the value of a certain signal 8 from FALSE to TRUE, in which FALSE describes the normal signal amplitude fluctuation and TRUE describes the signal fluctuation of a sensor arrangement with a fault condition. Figure 2 illustrates such a method. It is also possible to arrange a certain delay 9 between the fault generation moment and the fault detection moment for avoiding incorrect fault detections. The fault detection can also be carried out with a signal of a different type.

Figure 3 illustrates the inventive method as a block diagram example. The monitoring step 31 of the method is arranged for monitoring the amplitude fluctuation

of the signal of the knock sensor arrangement. The second step 32 is made for comparing the amplitude fluctuation of the signal and a certain limit value and the third phase 33 is arranged for detecting any faults in the knock sensor arrangement on the basis of the said comparison.

- 5 In the third phase the fault detection is positive when the amplitude fluctuation of the monitored signal is less than the said limit value. See figure 2. The method can also be arranged to delay the monitoring moment as described above.

As mentioned above, the fluctuation of the signal of the knock sensor can be a variance. The variance can be calculated as follows. The data points of the signal to
10 be monitored are

$$X = [x_1 \ x_2 \ \dots \ x_{n-1} \ x_n].$$

The average of the data points is

15
$$mean(X) = \frac{\sum_{i=1}^n x_i}{n}.$$

The variance is calculated as follows

$$\sigma^2 = \frac{1}{n-1} \cdot \sum_{j=1}^n (x_j - mean(X))^2.$$

- 20 The said data points can be calculated from the last monitoring window (a monitoring window is a time frame containing a certain number of data point observations), on the basis of which the variance is calculated. The method

described above is only one of many ways for calculating the variance. There are other ways as well of determining the fluctuation of the signal amplitude.

As can be seen, the embodiment according to the invention can be carried out by means of a number of solutions. Thus, it will be apparent that the invention is not
5 limited to the examples mentioned in this text. Thus, any inventive embodiment can be carried out within the scope of the invention.

Claims

1. A method for detecting a fault in a system used in connection with a piston-operated internal combustion engine,

characterized in that the method comprises the following steps for detecting a
5 fault in a knock sensor arrangement:

a step for monitoring the amplitude fluctuation of the signal of a knock sensor arrangement,

a second step for comparing the amplitude fluctuation of the monitored signal to a certain limit value and

10 a third step for detecting a fault in the knock sensor arrangement on the basis of said comparison.

2. The method according to claim 1, **characterized** in that in the third phase the fault detection is positive when the amplitude fluctuation of the monitored signal is below the said limit value.

15 3. The method according to claim 2, **characterized** in that amplitude fluctuation of the signal is variance of the signal.

4. The method according to claim 2 or 3, **characterized** in that the method comprises a delay operation for delaying the detection of a possible fault.

20 5. A fault detection apparatus for detecting a fault in a system used in connection with a piston-operated internal combustion engine, **characterized** in that the fault detection apparatus (4) is arranged to monitor the amplitude fluctuation of the signal of a knock sensor arrangement, to compare the amplitude fluctuation of the monitored signal to a certain limit value and to detect a possible fault in the knock sensor system on the basis of the said comparison.

6. The apparatus according to claim 5, **characterized** in that in the fault detection of the fault detection apparatus is positive when the amplitude fluctuation of the monitored signal is below the said limit value.

7. The apparatus according to claim 5 or 6, **characterized** in that the amplitude
5 fluctuation of the signal is the variance of the signal.

8. An apparatus according to claim 5–7, **characterized** in that the fault detection apparatus is carried out by means of a program.

9. An apparatus according to claim 5–7, **characterized** in that the fault detection apparatus is carried out by means of an ASIC circuit.

1/2

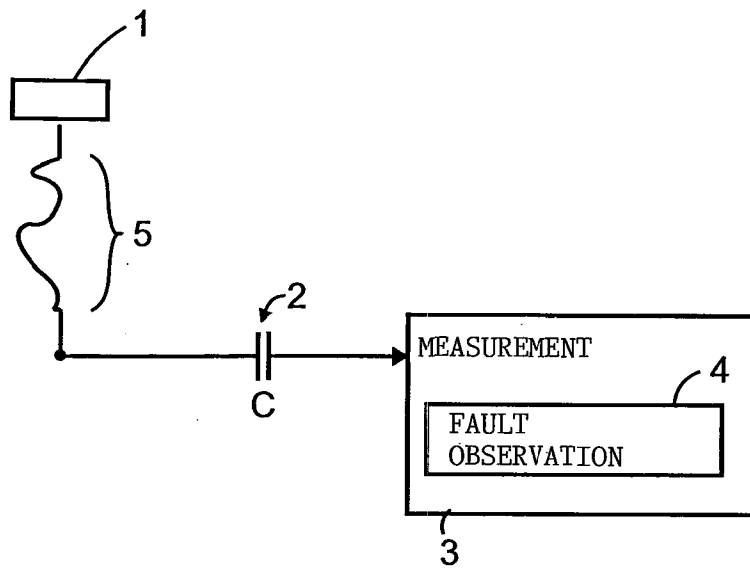


FIG. 1

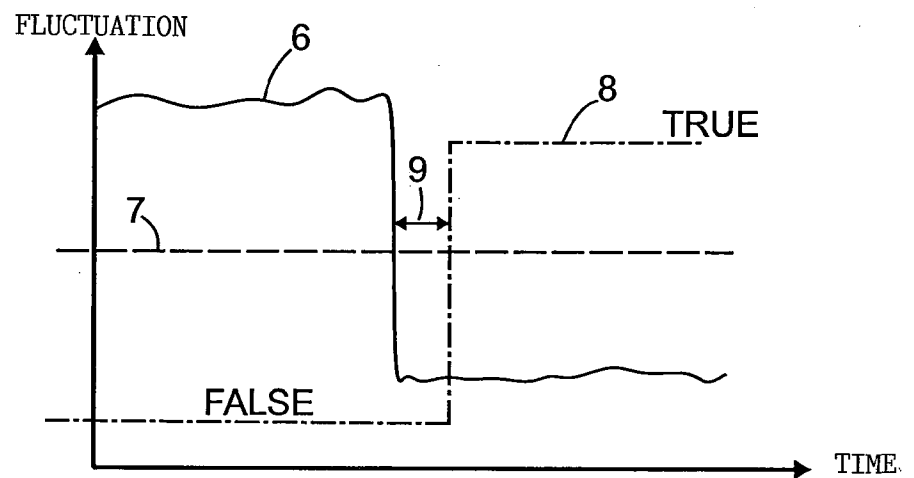


FIG. 2

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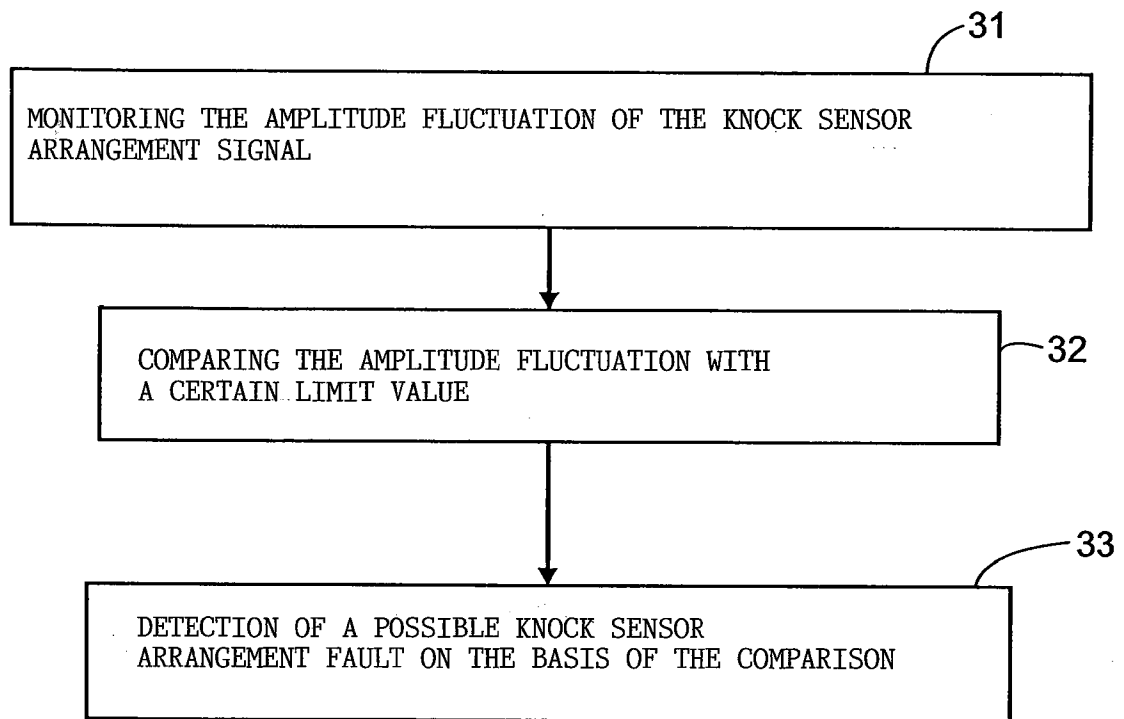


FIG. 3