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SYSTEM FOR ANALYSIS AND CORRECTION OF MOTOR MANAGEMENT

Summary. The innovative system, which was developed for analysis and correction of motor management, is determined for the solution of practical problems concerning the operation of the piston combustion engines. Programming of the ignition curves and fuel maps without relevant feedback, namely, without information obtained from the engine operation, increases the risk of detonation combustion, which can destroy the combustion engine. However, the main application area of this system is the development of an algorithm, which is specified for control of the combustion process based on the HCCI technology (Homogenous Charge Compression Ignition). Nowadays, the functional principle of the HCCI engine is one of the most effective possibilities on how to reach higher operational efficiency of the gasoline engine, that is, closer to the efficiency level of the diesel driving units.

Keywords: system, analysis, correction, motor management

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1. INTRODUCTION

Presently, many production companies around the world offer a wide range of electronics, including programmable electronic control units determined for installation in various models of piston combustion engines [1-3]. The programmable electronic control units enable to perform very detailed simulation of the engine ignition curve using either the 2-dimensional or the 3-dimensional simulation method. Application of the 2-dimensional method means that the actual value of the ignition advance angle is a function of the engine operational speed. The second possibility, that is, application of the 3-dimensional method, means that the angle of advanced ignition is not only a function of the engine speed, but also depends on the actual position of the throttle installed in the input pipe [4]. The throttle position determines the real amount of the fuel-air mixture that is delivered into the combustion engine.

However, a relevant problem occurs in the real operation of the combustion engine. This problem is that the values programmed during the simulation process (that is, the values of advanced ignition at various engine speed levels), do not usually correspond with reality. The individual impulses obtained from the measuring sensor changes with the given type of combustion engine. For example, variability of the impulse shape, which is typical for the input impulses as well as their delay, especially at higher engine speed levels (above 10,000 rpm); cause significant deformation of the output data correctness [5-7].

Based on this, an innovative system, which enables tuning the universal control unit to the concrete type of the engine-working regime, was developed by our research team. Further, this system defines the correction curve for the input values during the programming of the ignition curves and fuel maps.

2. ANALYSIS OF IGNITION IMPULSE

First, it is necessary to note the measuring of impulse produced by the impulse generator. This generator is connected with the engine crankshaft. The measuring process is based on the application of an oscilloscope. The main task of the measuring procedure is the collection of real data, which describe the analysed parameter. In the case that the values obtained from the measuring procedure are utilised within the engine control process, hence, it is necessary to ensure that the installed measuring apparatus fulfils the required metrological characteristics.

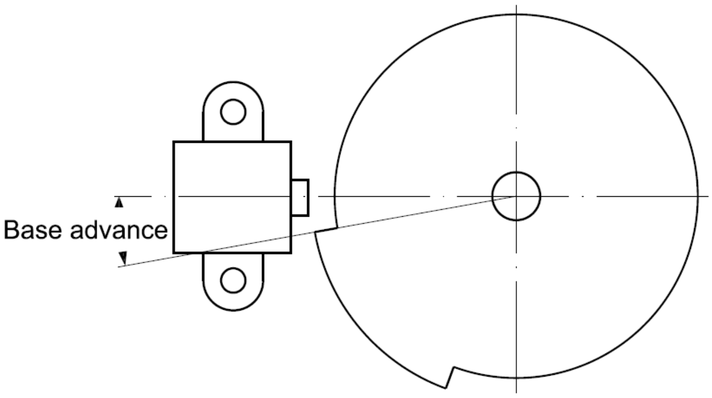

Fig. 1. Generator of impulses for combustion engine

Of course, this requirement is equally valid for the application of the above-mentioned oscilloscope. It is necessary to emphasise an important fact that every deviation, which occurs during the measuring activity, has a negative impact on the measuring process and it causes an incorrect function of the engine control unit. There are two main constructional parts of the impulse generator: the sensor of impulses and the rotor, which is directly connected with the crankshaft (Figure 1).

The value of basic advance is given by the setting of the generator. It corresponds to the "base advance" angle. Figure 1 illustrates the top dead centre position [6]. It is recommended to verify whether a real advance in the given engine is following the advance, which was determined using a stroboscopic lamp.

The sensor of impulses is a very important part of the electronic ignition system. It is necessary to apply such kind of sensor, which can satisfy the ascending edge condition (that is, the change of voltage) within the interval from 0 to 1.5 V. This requirement fulfils the inductive sensor of rotation [8-11].

An ignition spark is generated by the system of ignition and the spark-coil according to the impulses from the rotational sensor.

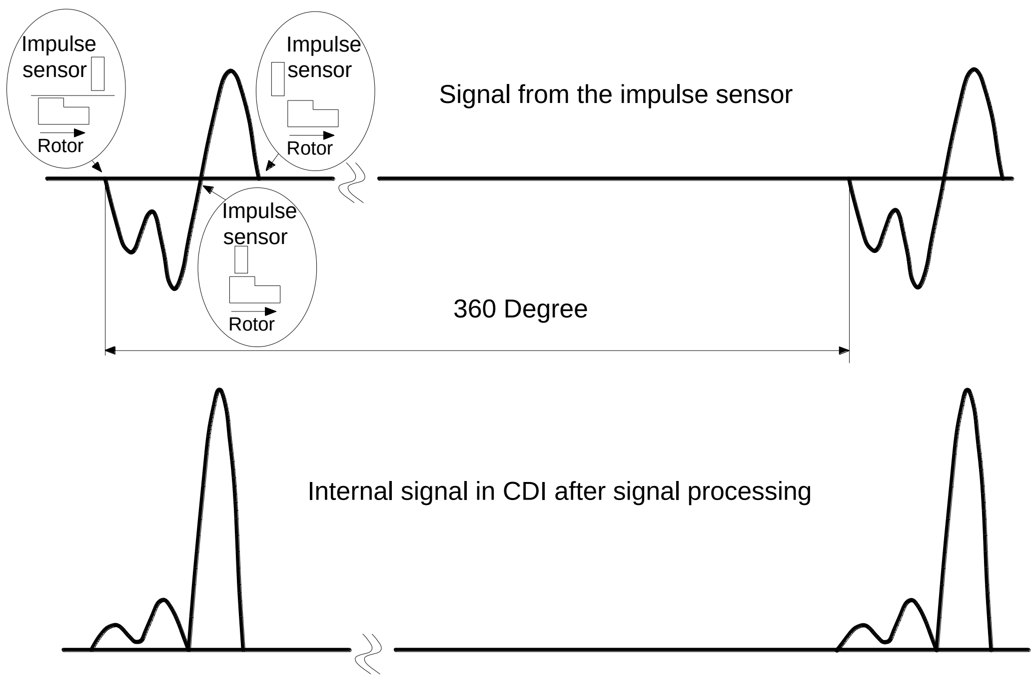

Fig. 2. Signal obtained from impulse sensor (part above) and in CDI (part below)

Figure 2 illustrates a shape of the impulse coming from the sensor of impulses in such form, which is presented from the oscilloscope. A specific position of the rotor, namely, the position opposite the sensor, is situated at 32º before reaching the top dead centre. This situation illustrates the left circle in Figure 2, whereby generation of the impulse starts just in this moment. Amplitude of the impulse is increasing in the negative direction regarding the central axis. After one half of amplitude begins a rapid reversing in such a moment, when the rotor is not in interference. The impulse amplitude further continues in the previous direction to reach the maximum negative value, and consequently, it is returning back to the central line. The impulse amplitude passes through the central line at approx. 7º before the level of the top dead centre. The above-described deviation creates a specific interval, which is called "the trigger interval", whereby this oscillation lasts during approx. 25º within rotation of the engine crankshaft. Finally, the positive amplitude occurs after crossing the projection lug in the rotor. The lug is visible in Figure 2 in the right circle.

The signal obtained from the sensor is the input signal to the control unit to be processed [12, 13]. The bottom part of Figure 2 illustrates the signals modified in the universal programmable control unit CDI. Further presented in the given figure is a mutual comparison of the processed signals and the scanned signals. It is visible from the same figure that the final version of the signal, which is processed in the control unit CDI, has the values situated only in the positive part of the axis, namely, with three main amplitudes. It is also evident that this signal is periodically repeating after each revolution of the rotor, that is, after every 360º.

3. PRINCIPLE OF THE MEASURING METHOD

The described system, which is determined for analysis and correction of motor management (Figure 3), consists of the electric motor, sensor of impulses, stroboscopic lamp, speed indicator and speed regulator. The rotor of the electric motor is connected with the disc protractor. The disc protractor generates an electric signal through a lug shaped in the form of a sector of a circle.

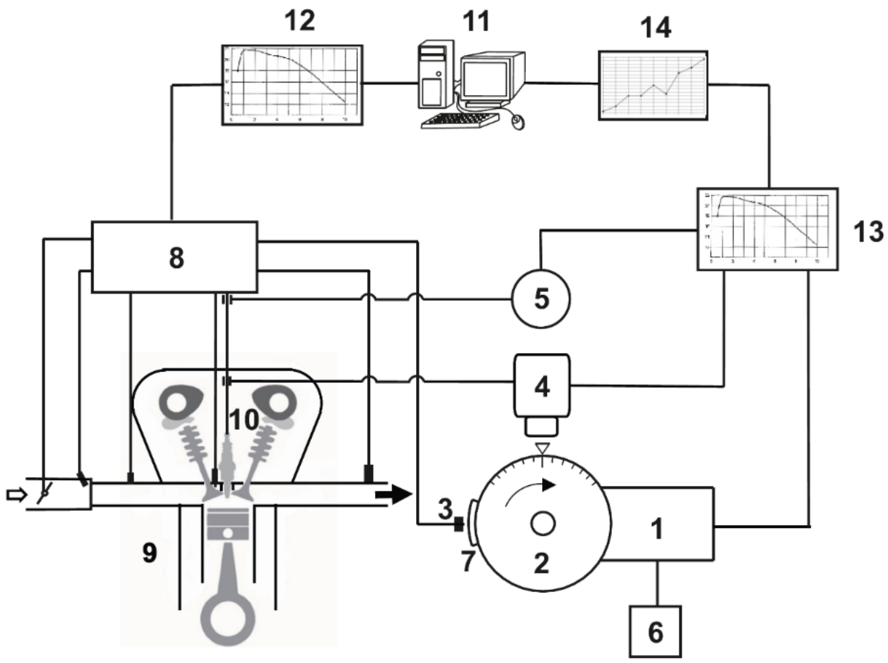

Fig. 3. System for analysis and correction of motor management

(1, 2 – high-speed electric motor with disc protractor; 3 – impulse sensor; 4 – generator of stroboscopic effect; 5, 6 – speed indicator with speed regulator; 7 – sector of circle, which generates impulses; 8 – control unit; 9 – combustion engine; 10 – spark plug; 11 – PC; 12 – input curve; 13 – real curve; 14 – correction curve)

The generated electric signal is detected by the impulse sensor, which is jointed to the engine control unit. The stroboscopic lamp is emitting a light ray oriented to the disc protractor just at the moment of simulated ignition of the fuel-air mixture. The speed indicator and the stroboscopic lamp are connected to the cable of the engine spark plug. The speed regulator enables utilising the whole spectrum of the engine speed. The time behaviour of the real ignition curve is recorded on the disc protractor using the stroboscopic method. Consequently, there is utilised the principle of comparison between the real ignition curve and the input ignition curve, which is installed into the engine control unit by a personal computer (PC). The result of this procedure is the correction curve, which serves for modification of the input data.

The main advantage of this solution is that it enables obtaining the correction curve relatively fast with a satisfactory accuracy. The question of deviations concerning the real output values of the ignition curve as well as the importance of the fuel map are especially relevant in the high-speed engine operational area and they have a significant influence on the operational stability of the HCCI combustion process.

4. APPLICATION OF THE PRESENTED SYSTEM

The presented measuring method was practically verified in the case of the experimental combustion engine. There was applied the control unit (CDI) during the whole measuring process. Regulation of the advanced ignition is based, in this case, on two adjustable ignition curves within the interval from 0 to 90° at the engine speed level from 100 to 15,000 rpm. It is possible to set all the functions and various operational ignition regimes using a PC equipped with a special software application called the Ignition Control. This application also enables to obtain online visualisation of the most important engine operation values, that is, the values of advanced ignition, engine speed as well as the inputs in digital and analogue forms. The ignition system is connected to the PC using an interface - USB cable [14-16].

There was programmed and implemented into the control unit, the input ignition curve through the PC. This ignition curve is a part of the control algorithm, which is utilised for control of the combustion process. After the start, the speed of the electric motor with the disc protractor was set on the required initial value using the speed regulator. The stroboscopic lamp is emitting a light ray to the disc protractor at the moment of simulated ignition of the fuel-air mixture. The result is a light effect of a seeming stopping of the disc protractor in the simulated ignition position. The disc protractor indicates the advanced ignition value, and at the same time, the speed indicator offers the corresponding engine speed value. It is obtained, in this way, one operational point of the real ignition curve. The speed regulator allows performing of a sequential change of the engine speed within the above-mentioned speed interval, and thus, it is possible to investigate the whole behaviour of the real ignition curve. The real ignition curve was compared with the programmed ignition curve using the PC and this process of comparison resulted in the correlation curve. The correlation curve serves for the input data modification.

5. CONCLUSIONS

The innovative measuring process described in this article enables to perform very precisely, a tuning procedure concerning the ignition control unit for each kind of combustion engine. This measuring methodology represents a significant contribution to the operational safety of the combustion engine. Namely, it reduces the risk of detonation combustion due to the elimination of incorrect outputs. In this way, it also significantly increased the global operational reliability of the combustion engine, especially during the application of the HCCI technology. This technology utilises the principle of self-ignition of the homogenous fuel mixture using the compression stroke. The homogenous fuel mixture is combusted in the whole combustion volume at the same time, that is, there is combusted almost the whole fuel mixture. Therefore, exploitation of the fuel is very effective, however, there are some serious problems concerning the application of the HCCI technology. The most relevant of them are high compression pressures, excessive heat release and demanding control of the self-ignition process. Development of an algorithm, which is determined for the operational control of the combustion process, is one of the main conditions that are necessary for the practical and reliable application of the HCCI technology. The system described in this article represents a significant contribution for better feedback regarding the control components of motor management.

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