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Experimental Studies of Cylinder Group State during Motoring

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Abstract

The paper describes a method for diagnosing the cylinder-piston group of internal combustion engines (ICE). The method is based on analyzing the results of measuring the dynamic compression during crankshaft motoring. The position of the maximum pressure in the combustion chamber, its magnitude and phase parameters give a complete picture of the technical state of the engine cylinder group. Measured parameters of the pressure signal were compared to instrumental measurements of air leakage in the cylinder-piston group as well as to the compression values. The developed method allows to combine all the positive aspects of existing and proposed methods and to solve the long-standing problem of improving the accuracy of estimating the technical state of ICE units and mechanisms. cylinders, rings, pistons, valves, displacement of phases timing. Experimental results are presented as graphs showing the inter-dependency of parameters of the processes under consideration.

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Keywords: Group piston-cylinder; engine diagnostics; the frequency of rotation of the crankshaft; compression of cylinders; waveform; modes; options.

1. Introduction

Resource options the best engine designs have reached a resource run in the 1–3 million km. For the Russian manufacturer of these figures is more modest, for example, for internal combustion engines «KamAZ» they amount to about 500 thousand km. Most cars in Russia are operated beyond the specified values of the resource parameters. Thus, the share of the cylinder-piston group (CPG) accounts for 10–15% of engine failures [1, 2]. It is known that

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the limiting condition of the internal combustion engine, in particular CPG, can be determined using properties start by rotating the crankshaft by the starter. Therefore, in practice the maintenance and repair of internal combustion engines it is necessary to control the parameters of the technical condition of CPG directly affecting start ability of the engine [1–18].

2. Methods

2.1. Theoretical research

The aim of the research is to improve the efficiency of diagnostics of CPG by controlling the parameters of the dynamic compression in the mode of rotation of the crankshaft of the engine using the starter. In the field of scientific research, the known methods of control of technical condition and diagnostics of CPG internal combustion engine: a method for using a gas flow meter; a method of blowing compressed air through the cylinders; the method of relative evaluation of CPG; method of diagnosis based on power measurement; method of diagnosis by measurement of current from the starter; the method of determining the state of individual cylinders, knowing the magnitude of the vacuum; a method based on the measurement of the amount of air passing through looseness of the combustion chamber at idle; the method that uses pneumatic testers, stethoscopes.

Having analyzed all the known methods, was chosen a promising. We intend to use for diagnosing individual elements of the CPG oscilloscope, model USB-Autoscope. The sensitivity and accuracy of the method proposed to be upgraded through the use of a scroll modes of the internal combustion engine by the starter [1, 8–13].

To determine the amount of air passing through the gaps CPG, we find the nature of the flow of air that occurs with subcritical or critical speed. Developed a mathematical model that takes into account the frequency of the scroll of the crankshaft, leakage of air into the gaps and other factors. It allows simulating the pressure variation in the combustion chamber and then will help to compare with the experimental data.

2.2. Methodology of experiment

Experimental studies were carried out on the engine «ZMZ-4062» when using oscilloscope USB-Autoscope, with the help of the device K-69, by means of measurement of the compression. It was established that the pressure signal has a large information content, if scroll through the crankshaft starter.

The technical condition of CPG should be evaluated using a set of structural parameters. Among them are the geometrical dimensions of height and diameter of the cylinder, the shape of the piston rings in a free state, the sizes of the rings and the piston, the quality of the mating surfaces, the relative positions relative to each other. None of the known methods of diagnostics allows to solve such a complicated problem of diagnostics of CPG. One of the solutions is to combine two methods into one. In the model of the compression process to simulate the wear rings, we used a constant value of clearances of air leakage. In the simulation of the wear of cylinder liners of internal combustion engines, we used the change in the gaps of air leakage according to a certain law with the offset of the rotation angle of the crankshaft. The model will be more accurate if it is to introduce the dependence of the gaps of air leakage when turning the crankshaft [1, 9, 13]. This dependence is easy to obtain if you use differential pressure sensor to measure the compression of CPG (Fig. 1).

The analysis of Fig. 1 shows that the oscilloscope USB-Autoscope is connected to the sensor location crankshaft to control the rotational speed of the internal combustion engine. To remove a signal phase pressure connected differential pressure sensor [9, 13]. The combination of these methods of diagnosis enables comprehensive control of CPG engine.

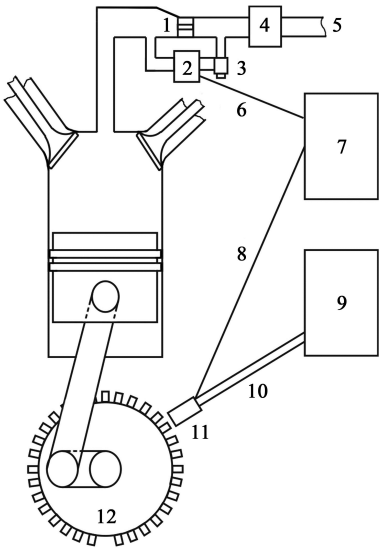

Fig. 1. Scheme of the experimental setup: 1 – section for the passage of air; 2 – differential sensor; 3 – valve; 4 – stop valve; 5 – supply line air, 3–6 [bar]; 6 – pressure signals, and clearance; 7 – oscilloscope USB-Autoscope ; 8 – position signal of the crankshaft; 9 – power supply; 10 – wiring for switching; 11 – crankshaft position sensor; 12 – control disk on the crankshaft pulley (58 cuts) and the missing notches on the disc

3. Results

As a result of experimental studies the dependence of the pressure change at the end of the compression stroke and the rotational speed of the crankshaft of the engine for the case of wear of the piston rings. It is established that an increase in the size of the wear rings reduces pressure at the end of the compression stroke. Moreover, when larger amounts of wear of the pressure change is more intense when increasing the speed of the scroll.

Also conducted the experiment with different parameters of the technical condition of the cylinders. The dependencies are obtained, where the air pressure is changed similarly as in case of wear of the piston rings. However, when there is wear of the piston rings, it also changes the phase of the pressure. This case is shown in the graph Fig. 2.

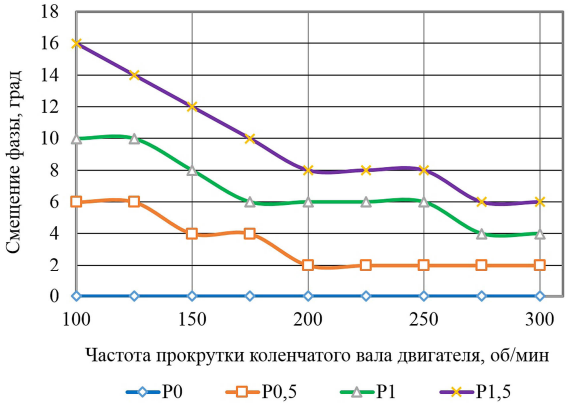

Fig. 2. The result of wear of the piston rings. The dependence of the phase shift of the maximum pressure at the end of the compression stroke relative to the upper dead point from the values of the rotational speed of the crankshaft of the engine: line P0, P0,5, P1, P1,5 – the values of the total cross sections of equivalent air leakage, respectively, [mm]: 0.1; 0.5; 1.0; 1.5

4. Conclusion

An important criterion for rejection of the engine are its properties at start-up. For better engine starting it is necessary to submit a spark at the moment of maximum pressure at the end of the compression stroke. In extremely worn engines phase changes are evident in the moment of maximum pressure. Schedule of Fig. 2 shows that the more rings worn, the greater the displacement of phases timing (line P1,5). This affects the time of filing of a spark to ignite the mixture. In cars you can correct the time of filing of the ignition, using the data in Fig. 2, it is thus possible to improve start ability of the internal combustion engine.

5. Findings

The experimental data allow us objectively evaluate the technical condition of CPG engine under various conditions: the state of battery charge, the frequency at which the scroll a cranked shaft a starter, ability of the vehicle to the diagnosis. The proposed method allows high accuracy to distinguish between the failure of the cylinder, the wear of the rings and valves.

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