MEASUREMENTS OF MAXIMUM CRANKCASE PRESSURE FOR EVALUATION OF THE PISTON-RINGS- CYLINDER ASSEMBLY

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Abstract

In the paper is presented statistical analysis of the effect of compression-ignition engine working time on the phenomenon of exhaust gas maximum pressure increase in crankcase and cylinder liner, pistons and rings wear. Characteristics of the crankcase maximum pressure variations were made for the start-up speed and for selected rotational speeds of the 359 compression-ignition engine crankshaft as well as micrometric measurements of the cylinder liner and pistons and rings wear. The engine was operated under normal traction conditions while pressure analyses and cylinder liner micrometric measurements were made, respectively, after an operational run of 204864 km. Crankcase exhaust gas maximum pressure measurements were made both with air vent open and closed for a cold (lubricating oil temperature of 285 K) and a warm engine (333 K). Basing on the analysis of obtained examination results, it was showed that crankcase exhaust gas maximum pressure measurement (also during the start-up) may be used for determination of engine run and life. Average and maximum wear and tear of cylinder liners, maximum wear and tear of pistons in the perpendicular plane to the piston pin axis, dependency of maximum crankcase pressure in the function of operational mileage of a 359 engine for lubricating oil temperature of 333 K, dependency of maximum crankcase pressure in the function of operational mileage for lubricating oil temperature of 285 K are presented.

Keywords: *blow-by, wear, piston, rings, cylinder, crankcase*

1. Introduction

The piston-rings-cylinder (PRC) system has to secure a slide fit of the working space [8-9]. Therefore, there is a clearance between a piston, rings and a cylinder providing a possibility of the movement of piston with rings, which leads to charge losses in the form of exhaust gas scavenging into engine crankcase [7, 14]. As a result of the wear and tear of piston, rings and cylinder bearing surface, a clearance securing the slide fit enlarges [1-2, 4]. This causes that exhaust gas scavenging increases, which in turn results in an increase in crankcase exhaust gas pressure [5, 11-13]. This is why it was decided to check whether a measurement of maximum crankcase pressure can be a diagnostic parameter attesting to the wear and tear of the PRC system.

2. Measurement method

When estimating the usefulness of crankcase exhaust gas pressure measurements for evaluation of cylinder liner wear degree, two criteria were adopted. First of all, results of crankcase exhaust gas pressure examination should be considerably correlated with cylinder liner wear and secondly, dynamics of determined signal change should be as large as possible. It results that considerably correlated variables should be characterised by the correlation coefficient r. It is known from experience that in case of statistical diagnostic analyses it is rather difficult to obtain such a considerable value of correlation coefficient and it requires large repeatability of measurement conditions. In this case, growth of exhaust gas pressure in crankcase induced by a rise in exhaust gas scavenging intensity in result of the increase of wear in the PRC group, in particular of cylinder liner wear, is regarded as a determined signal change. The following value was adopted as a dynamics index d_p:

$$d_p = \frac{X_m - X_o}{X_o}, \tag{1}$$

where:

X_m - is a boundary value of signal indicating the necessity of performing a repair or taking an object out of service,

X_o - is an initial value of signal characterising a new object after termination of the running-in period.

3. Test results

For example, average wear and tear is presented in Fig. 1, while maximum wear and tear of respective cylinder liners for a 359 engine after a mileage of 204864 km is presented in Fig. 2.

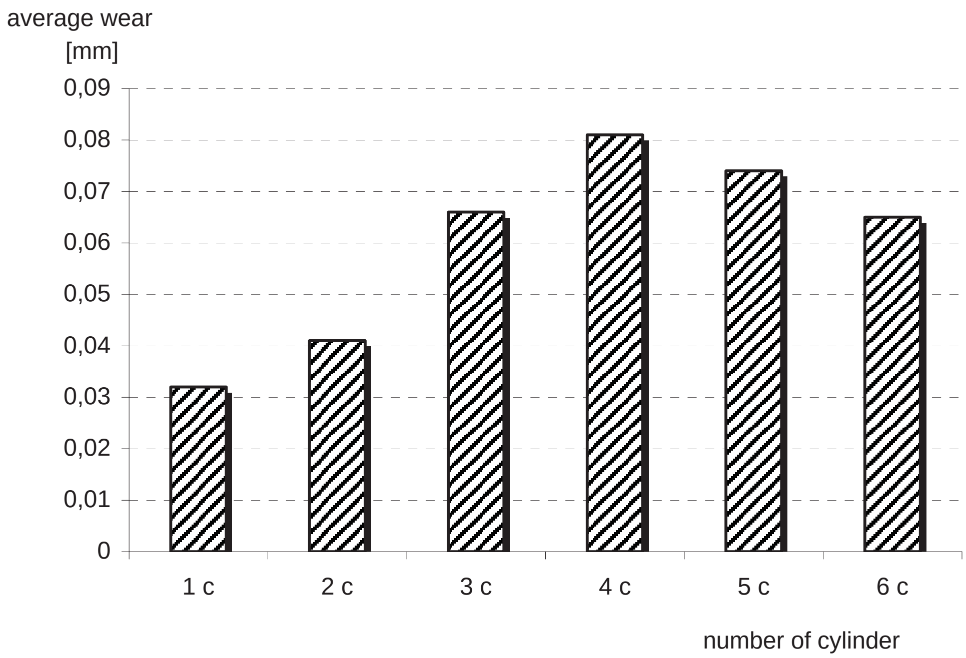

Fig. 1. Average wear and tear of cylinder liners of a 359 engine after a mileage 204864 km

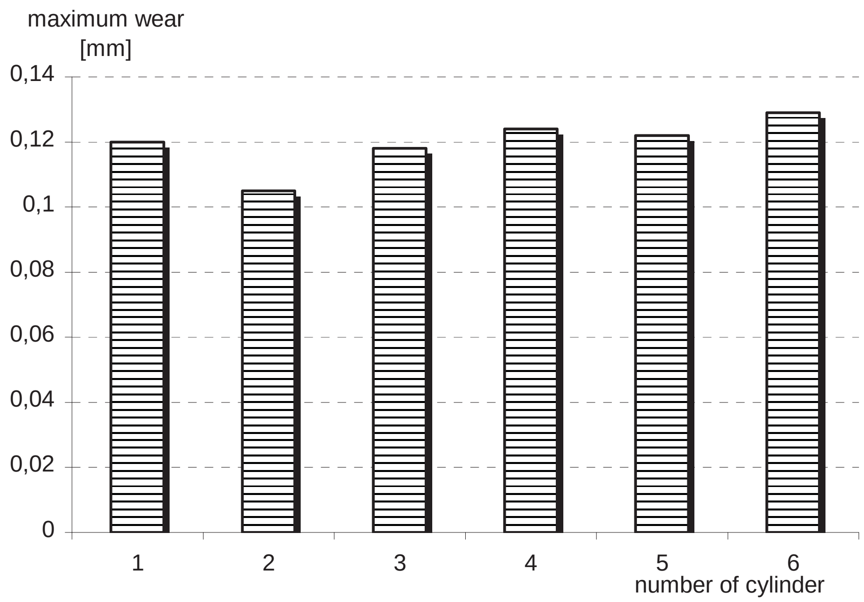

Fig. 2. Maximum wear and tear of cylinder liners of a 359 engine after a mileage of 204864 km

In Fig. 3, maximum wear and tear of pistons in the perpendicular plane to the piston pin axis after a mileage of 204864 km is presented.

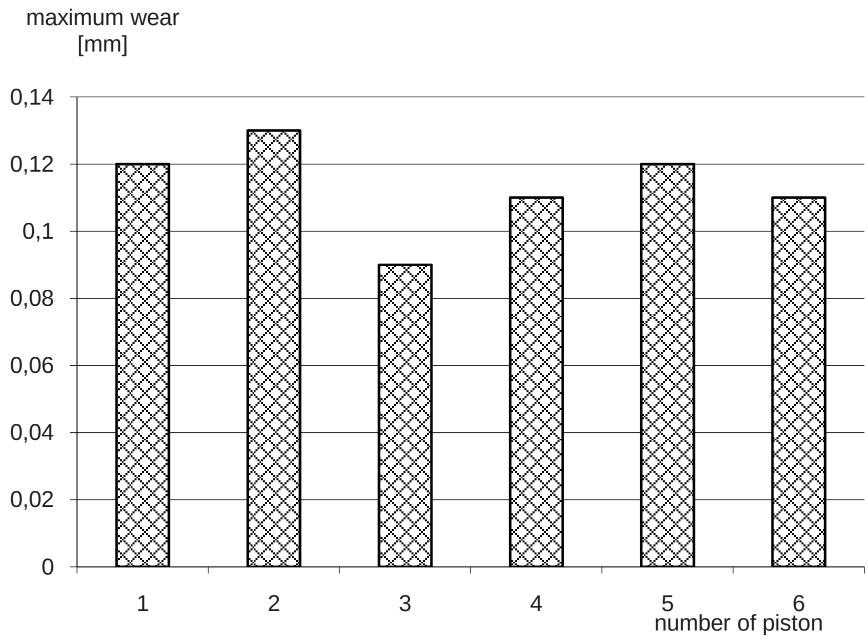

Fig. 3. Maximum wear and tear of pistons in the perpendicular plane to the piston pin axis of a 359 engine

Mean wear values for the height of respective rings were as follows:
- for first packing rings – 0.019 mm,
- for second packing rings – 0.012 mm, and
- for third packing rings – 0.009 mm.

Mean values from maximum wear values for the breadth of respective rings were as follows:
- for first packing rings – 0.189 mm,
- for second packing rings – 0.144 mm, and
- for third packing rings – 0.112 mm.

Mean wear values for the breadth of respective rings were as follows:
- for first packing rings – 0.151 mm,
- for second packing rings – 0.113 mm, and
- for third packing rings – 0.098 mm.

The size of piston-ring joint clearance in all packing rings after their insertion into a cylinder hole was larger that of entrance clearances by:
- 1.44 mm for first packing rings,
- 1.06 mm for second packing rings, and
- 0.93 mm for third packing rings.

In order to analyse a decrease in ring elasticity, crank pin effort values were measured at ring closure to piston-ring joint sizes measured after insertion into cylinder liner and comparison with initial values. The elasticity decrease was on average as follows:
- for first packing rings – 7.1 N,
- for second packing rings – 5.2 N, and
- for third packing rings – 2.3 N.

In Fig. 4, a diagram of the effect of operational mileage of a 359 engine on the value of maximum crankcase pressure for lubricating oil temperature of 333 K is presented.

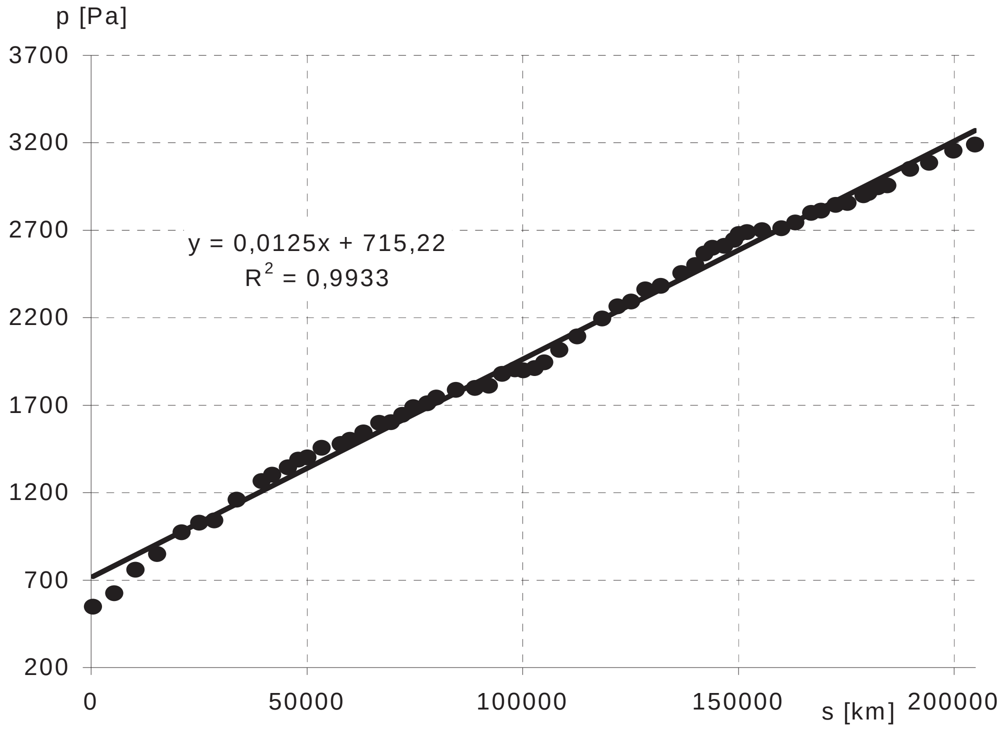

Fig. 4. Dependency of maximum crankcase pressure in the function of operational mileage of a 359 engine for lubricating oil temperature of 333 K

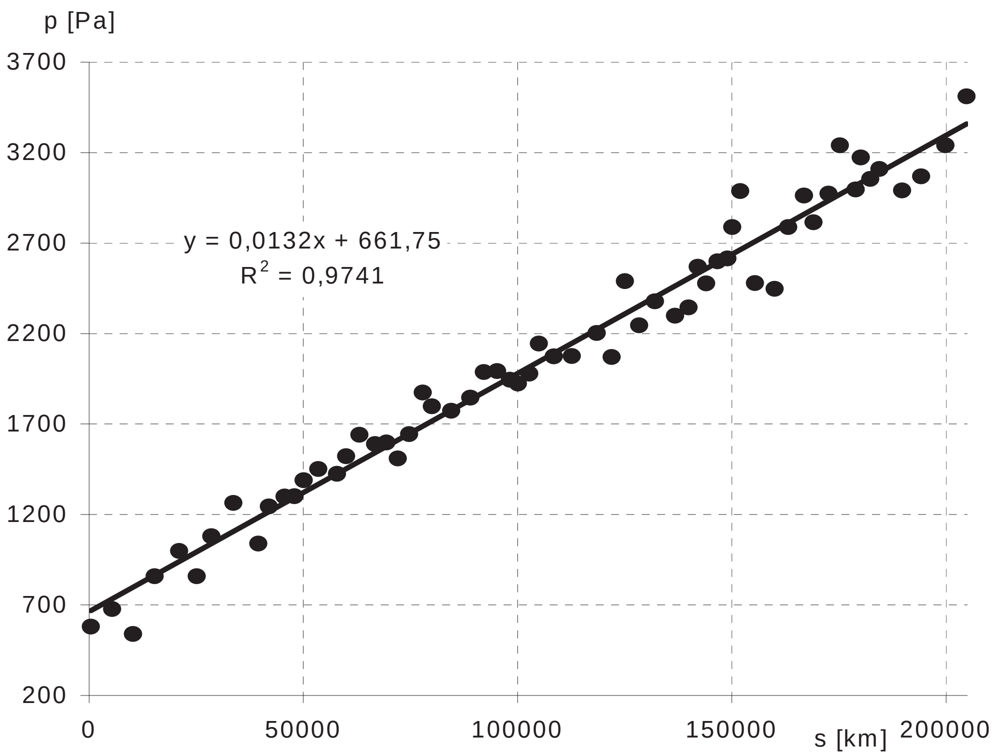

Fig. 5. Dependency of maximum crankcase pressure in the function of operational mileage of a 359 engine for lubricating oil temperature of 285 K

In Fig. 5, a diagram of the effect of operational mileage of a 359 engine on the value of maximum crankcase pressure for lubricating oil temperature of 285 K.

On the diagrams, close linear dependency of the effect of PRC group wear and tear on the value of maximum exhaust gas pressure in the crankcase of a 359 engine.

4. Conclusions

When evaluating the usefulness of maximum crankcase pressure measurement in the function of operational wear and tear of the PRC group, it should be said that dynamics index d_p assumes a value of $d_p = 3.48$ for a warm engine, whereas a value of $d_p = 4.31$ far a cold engine. On the other hand, coefficient of correlation amounts to $r^2 = 0.99$ for a warm engine and to $r^2 = 0.97$ for a cold engine. Thus, it can be explicitly stated that the increase of crankcase pressure is closely correlated with an increase in the wear and tear in the piston-cylinder group.

On the other hand, it should be kept in mind that a prevailing majority of piston combustion engines is being produced at present with a turbo-supercharger. The popularity of turbo-supercharged engines grows, which results from lower and lower costs connected with turbo-supercharger production and upgrading the operational parameters obtained by engine (power rating, torque) [10]. Therefore, attention should be paid to the venting system of engine crankcase. A too large overpressure developing in the crankcase acts unfavourably on turbo-supercharger lubrication system. Every turbo-supercharger has a dynamic packing of the labyrinth type which are very sensitive to the elevated level of overpressure in engine crankcase. Then, a free outflow of the oil lubricating turbo-supercharger bearings to the oil sump is much laboured or even prevented. Thus, the use of maximum crankcase pressure measurement method can be limited or even prohibited.

The excessive overpressure developing in the crankcase can be induced by wear and tear in the piston-rings-cylinder system [3, 6]. Thus, an examination of exhaust gas scavenging into engine crankcase can be made or even is recommended after longer service time for proper turbo-supercharger operation. Excessive exhaust gas scavenging induces faster oil aging, emulsifies with the oil, and decreases its lubricating properties.

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