UDC 621.43.016:621.89

PARAMETERS INFLUENCING THE INTENSITY OF WEAR OF INTERNAL COMBUSTION ENGINE CYLINDERS

O. Lymar, *PhD;*
D. Marchenko, *PhD;*
I. Okhrimenko, *student;*
A. Oliynyk, *student*
Mykolayiv National Agrarian University

Determining cylinder wear using calculation methods and predicting engine durability are of great practical importance. In addition, knowledge of the wear diagram of designed engines is necessary for the development of optimal cylinder manufacturing technologies that ensure maximum engine life during operation. Obtaining an operational wear diagram for new engines requires a significant amount of time and high material costs. To achieve reliable results, it is necessary to conduct research on many engines over a long period. Creating a mathematical model for calculating cylinder wear significantly speeds up the process and reduces costs, allowing you to obtain the necessary data several times faster and cheaper. However, to date, there is no single and reliable method for calculating cylinder wear. This is due to the large number of factors that affect the wear of internal combustion engine cylinders, and their different effects on different engines and in different operating conditions. All factors that affect the intensity of cylinder wear can be conditionally divided into two groups: internal and external. Internal factors include those that cannot be changed during operation, in particular: the design features of the engine and the physical and mechanical properties of the rubbing materials (bushings, rings, piston). External factors include a large number of variable parameters that can vary during operation, such as: used oils, air, fuel and oil purity, operating modes (load, speed, temperature), as well as indicator parameters of engine operation (compression ratio, boost ratio, maximum combustion pressures, gas temperatures, etc.).

The main problem is that external factors that affect the friction of piston rings against the cylinder vary along the height of the cylinder and differ at different points in it. Even when all internal and external factors are taken into account, cylinder wear is caused by friction between the piston rings (which can be from 3 to 8 per piston) and the piston. Each ring operates under different friction conditions and in different areas of the cylinder. Cylinder wear is the result of the complex influence of all factors.

When creating a mathematical model of cylinder wear, an important role is played by the selection of the main factors that significantly affect this process. To simplify the calculations, it is necessary to make certain assumptions and highlight the main factors. In modern engines that have a reliable air and fuel cleaning system and use high-quality oils, the influence of some factors can be ignored, taking them as constant and such that only shift the wear curve. This applies, for example, to the type of fuel or oil. The physical and mechanical properties of rubbing materials do not change the nature of the wear curve, but only affect its absolute values, so they can also be ignored.

Among the factors that cannot be ignored are objectively existing and variable parameters along the cylinder height: friction pressure, piston speed and cylinder surface temperature. So, the main factors that affect cylinder wear are:

• gas pressure in the cylinder;
• instantaneous piston speed;
• cylinder wall surface temperature.

Other internal and external factors can be considered secondary and not taken into account at the first stage, since their influence is manifested not in changing the qualitative nature of wear, but only in shifting the wear diagram by a constant value in the direction of increasing or decreasing the ordinates. For example, the type of fuel or oil can affect the wear diagram, but this only changes the overall level of wear. Similarly, the physical and mechanical properties of rubbing materials (rings, piston and cylinder) do not change the shape of the wear diagram, but only its magnitude.

Regarding the consideration of certain factors or the calculation of the wear diagram, it should be noted that the methodology developed by the authors allows, if necessary, to expand it by including additional factors, both primary and secondary, that can affect the wear diagram.

Thus, the following conclusions can be drawn:

• Changing the engine operating modes has a significant impact on the nature and magnitude of wear of diesel cylinder liners.

• For each diesel engine, there is an optimal crankshaft speed at which bushing wear is minimal.

• Increasing the boost ratio has a positive effect on the nature of the wear pattern, smoothing it out.

• Increasing the temperature of the bushing surface reduces the intensity of wear and has a positive effect on the resource of the cylinder-piston group parts.

• The most desirable way to increase the engine resource is to increase the boost ratio when operating at optimal speeds and ensuring the maximum possible and permissible temperature level for the cylinder-piston group parts.

References

1. Vasilyuk V. V. Improving the diagnosis of the technical condition of the cylinder-piston group of engines: dissertation ... candidate of technical sciences: 05.05.03. Dnipro, 2019.
2. Dyachenko V. G. Internal combustion engines. Theory, design and principles of calculation: textbook. Kharkiv: Khai, 2007.
3. Dumchykov V. O. Wear of automobile engine cylinders, reasons for its occurrence // Materials of the XVI International Youth Forum "Youth and Agricultural Machinery in the XXI Century". Kharkiv: KhNTUSG, 2020. P. 53.
4. Marchenko, D., & Matvyeyeva, K. (2022). Increasing warning resistance of engine valves by gas nitrogenization method. Problems of Tribology, 27(2/104), 20–27. https://doi.org/10.31891/2079-1372-2022-104-2-20-27.
5. Kononov, Y., & Lymar, O. (2025). Investigating the stability of oscillations of rectangular plates in an infinitely long rectangular parallelepiped with an ideal fluid. Eastern-European Journal of Enterprise Technologies, 1(7 (133), 14–21. https://doi.org/10.15587/1729-4061.2025.323200.
6. Lymar O., Marchenko D., Khramov M. Use of technological fluids coolants in cutting processing. Food security of Ukraine in the conditions of the war and post-war recovery: global and national dimensions. International forum = Food security of Ukraine in the conditions of the war and post-war recovery: global and national dimensions. International forum : reports of participants of the international scientific and practical conference (Mykolaiv, May 30-31, 2024) / Ministry of Education and Science of Ukraine ; Mykolaiv National Agrarian University. Mykolaiv: MNAU, 2024. P. 90-92. DOI: https://doi.org/10.31521/978-617-7149-78-0-28.
7. Marchenko, D., Artyukh, V., & Matvyeyeva, K. (2020). Analysis of the influence of surface plastic deformation on increasing the wear resistance of machine parts. Problems of Tribology, 25(2/96), 6–11. https://doi.org/10.31891/2079-1372-2020-96-2-6-11.
8. Archard J.F. Contact and rubbing of flat surfaces. J Appl Phys1953; 24: 981–988.2. Lai F.Q., QuS.G., Yin L.M., et al. Design and operation of a new multifunctional wear apparatus for engine valve traincomponents. Proc IMechE, Part J: J Engineering Tribology2018; 232: 259–276.3.
9. Lewis R., Dwyer-Joyce R.S. Wear of diesel engine inlet valves and seat inserts. Proc IMechE, Part D: J Automobile Engineering2002; 216: 205–216.4.
10. Forsberg P., Debord D., Jacobson S. Quantification of combustion valve sealing interface sliding –a novel experimental technique and simulations. Tri Int 2014; 69: 150–155.6.
11. Mascarenhas L.B., GomesJ.D., Beal V.E., et al. Design and operation of a high temperature wear test apparatus for automotive valve materials. Wear2015; 342–343: 129–137.7.
12. Dykha A.V. MarchenkoD.D., ArtyukhV.A., Zubiekhina–KhaiiatO.V., Kurepin V.N. Study and development of the technology for hardening rope blocks by reeling. Eastern–European Journal of Enterprise Technologies. Ukraine: PC «TECHNOLOGY CENTER». 2018. No2/1 (92) 2018. pp. 22–32. DOI: https://doi.org/10.15587/1729-4061.2018.126196.