result is obtained by using components, elicited from architectural issues. In addition, the decomposition not only refines the evaluation outcome but also indicates which specific component exerts a critical influence on the applicability of a given variation.

References

[1] O. Lytvynov and D. Hruzin, “Decision-making on Command Query Responsibility Segregation with Event Sourcing architectural variations,” Technology audit and production reserves, vol. 4, no. 2, Aug. 2025, doi: https://doi.org/10.15587/2706-5448.2025.337168.

[2] A. Bant. “Cost Optimization Done Right – Even in a Volatile Economy” www.gartner.com. Accessed: Oct. 11, 2025. [Online.] Available: https://www.gartner.com/en/insights/cost-optimization

[3] M. Barbacci, M. H. Klein, T. Longstaff, C. B. Weinstock, “Quality Attributes,” Carnegie Mellon University, Pittsburgh, PA, USA, Rep. CMU/SEI-95-TR-021, ESC-TR-95-021, Dec. 1995.

[4] D. Gobov, O. Zuieva, “Software Quality Attributes in Requirements Engineering,” International Journal of Information Technology and Computer Science, vol. 17, no. 4, Aug 2025, doi: https://doi.org/10.5815/ijitcs.2025.04.04.

[5] S. Aljarallah R. Lock, “A Comparison of Software Quality Characteristics and Software Sustainability Characteristics,” presented at the ISCSIC 2019: 2019 3rd International Symposium on Computer Science and Intelligent Control, Amsterdam, Netherlands, Sep. 25 - 27, 2019, pp. 1-11, doi: 10.1145/3386164.3389078.

[6] D. Sobhy, R. Bahsoon, L. Minku, R. Kazman, “Evaluation of Software Architectures under Uncertainty: A Systematic Literature Review,” ACM Transactions on Software Engineering and Methodology, vol. 30, no. 4, Jul. 2021, doi: https://doi.org/10.1145/3464305.

[7] Microsoft documentation “CQRS pattern” learn.microsoft.com. Accessed: Oct. 11, 2025. [Online.] Available: https://learn.microsoft.com/en-us/azure/architecture/patterns/cqrs

[8] Microsoft documentation “Event Sourcing pattern” learn.microsoft.com. Accessed: Oct. 11, 2025. [Online.] Available: https://learn.microsoft.com/en-us/azure/architecture/patterns/event-sourcing

[9] M. Fowler “CQRS” martinfowler.com. Accessed: Oct. 11, 2025. [Online.] Available: https://martinfowler.com/bliki/CQRS.html

[10] R. Kazman, M. Klein and P. Clements, “ATAM: Method for Architecture Evaluation,” Product Line Systems, Pittsburgh, PA, USA, Rep. CMU/SEI-2000-TR-004, ESC-TR-2000-004, Aug. 2000.

[11] D. D. Pompeo, M. Tucci, “Quality Attributes Optimization of Software Architecture: Research Challenges and Directions,” presented at the 3rd International Workshop on Model-Driven Engineering for Software Architecture (MDE4SA 2023), Jan. 8 2023, doi: https://doi.org/10.1109/ICSA-C57050.2023.00061.

[12] J. Nielsen, “What Is Usability?”, in *User Experience Re-Mastered*, 1st ed., Elsevier, 2009, pp. 3-22.

[13] S.K. Karna and Dr. R. Sahai, “An Overview on Taguchi Method”, International Journal of Engineering and Mathematical Sciences, vol. 1, Jun. 2012, pp. 11-18.

[14] O. Lytvynov and D. Hruzin, “Critical causal events in systems based on CQRS with Event sourcing architecture,” Radio Electronics Computer Science Control, no. 3, Nov. 2024, doi: https://doi.org/10.15588/1607-3274-2024-3-11.

[15] M. Minsky, “A Framework for Representing Knowledge,” MIT Research Lab, Cambridge: MIT-AI Laboratory Memo 306, Jun 1974.

UDC 004.94:621.43.016

INFORMATION SYSTEM FOR ASSESSING WEAR OF INTERNAL COMBUSTION ENGINE CYLINDERS

Keyda A.A., Cherevko S.L., Lymar O.O., Marchenko D.D.
(limaroo@mnau.edu.ua, marchenkodd@mnau.edu.ua)
Mykolayiv National Agrarian University (Ukraine)

In the course of the scientific work, the methodology for calculating the wear characteristics of internal combustion engine cylinders was investigated. The factors that have the greatest impact on the

wear of friction surfaces in the cylinder -piston group of an internal combustion engine were analyzed. Based on the conditions that affect the intensity of cylinder wear, it was found that a number of factors can be neglected and their values can be taken as fixed, increasing or decreasing wear depending on the type of fuel and lubricants used.

Determining cylinder wear by calculation methods and predicting engine durability is of great practical importance. In addition, determining the wear diagram of designed engines is necessary for developing the optimal technology for manufacturing cylinders that ensure maximum engine life during operation. Obtaining an operational diagram of cylinder wear of created engines requires a lot of time (several years) and large material costs [1]. For reliability, this must be data on many engines and for a long period of time. Creating a mathematical model for calculating cylinder wear significantly speeds up and significantly reduces the cost of obtaining the necessary results. But so far, a comprehensive and reliable method for calculating cylinder wear has not been created. This is due, first of all, to the huge number of factors that affect the wear of internal combustion engine cylinders and their different effects in different engines and different operating conditions.

All factors affecting the intensity of cylinder wear can be divided into two groups: internal and external. Internal factors include, first of all, factors that cannot be changed during operation, these are: design features of the engine and physical and mechanical properties of materials of rubbing parts (bushings, rings, pistons) [2 - 4]. External factors include a lot of conditions that can change during operation. These are: used oils, cleanliness of air, fuel and oil operating modes (load, speed, thermal mode); indicator parameters of engine operation (compression ratio, boost ratio, maximum combustion pressure, gas temperature, etc.).

But the main difficulty lies in the fact that external factors affecting the friction of the rings against the cylinder vary depending on the position of the piston along the height of the cylinder and are different at each point. Even with all the known internal and external factors of influence, the cylinder wears out from the friction of the piston rings (and there are from 3 to 8 of them on the piston) and the piston [5]. Moreover, each ring works in different conditions and friction zones, so we can conclude that cylinder wear is the result of the integral influence of all factors.

When building a mathematical model of cylinder wear, the main difficulty is to determine and isolate the main factors, the influence of which on cylinder wear is decisive. To reduce the number of variables, it is necessary to make reasonable assumptions and isolate the main ones. In modern engines with a reliable air and fuel cleaning system and when using high-quality oils, the influence of these factors can be ignored and accepted as constants that shift the wear curve proportionally towards increasing or decreasing wear depending on the type of fuel or oil used.

The physical and mechanical properties of the materials of the rubbing parts do not affect the nature of the wear diagram, but affect the absolute values of the wear value and therefore they can also be ignored.

Factors that cannot be ignored include friction, which objectively exists and varies along the height of the pressure cylinder, piston speed and cylinder surface temperature, i.e. according to the authors, the main factors affecting cylinder wear are:

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

As for other internal and external factors, they can be considered secondary, and in the first approximation they can be ignored, since the influence of these factors on the wear diagram is not manifested in a change in its qualitative nature, but is reduced only to a change in the wear diagram as a whole by a constant value in the direction of decrease or increase. Such, for example, is the influence on the wear diagram of fuel or lubricant: in modern engines that have a reliable air and fuel purification system, when using high-quality lubricants, it can be assumed that the constant change in the wear diagram is determined by the type of fuel or lubricant used [6]. Similarly, the change in the diagram is influenced by the physical and mechanical properties of the materials of the rubbing parts - rings, piston and cylinder.

Regarding the accounting of certain factors or the calculation of the wear diagram, it is necessary to emphasize the following: the developed methodology for calculating wear characteristics is constructed in

such a way that, if necessary, it allows its expansion in the direction of accounting for both the main and all secondary factors that in one way or another affect the wear diagram [7].

Thus, the following conclusions can be drawn:

- Changing engine operating modes significantly affects the nature and amount of wear on diesel engine cylinder liners.
- For each diesel engine, there is an optimal crankshaft speed at which bushing wear is minimal.
- An increase in the compression ratio and maximum combustion pressure leads to further differentiation of the bushing wear intensities in the upper zone and in the rest of its part.
- Increasing the degree of inflation has a positive effect on the nature of the bushing wear pattern, leveling it.
- Increasing the temperature of the bushing surface reduces the intensity of wear and has a positive effect on the service life of the parts of the cylinder -piston group.

The most desirable way to increase engine power is to increase the boost ratio when the engine is operating at optimal speeds and to ensure the maximum possible and permissible temperature level of the cylinder - piston group parts internal combustion engine cylinders was investigated. The factors that have the greatest impact on the wear of friction surfaces in the cylinder - piston group of an internal combustion engine were analyzed. Based on the conditions that affect the intensity of cylinder wear, it was found that a number of factors can be neglected and their values can be taken as fixed, increasing or decreasing wear depending on the type of fuel and lubricants used.

References

[1] J. B. Heywood, *Internal Combustion Engine Fundamentals*, 2nd ed. New York: McGraw-Hill Education, 2018.

[2] R. Isermann, *Engine Modeling and Control: Modeling and Electronic Management of Internal Combustion Engines*, 2nd ed. Cham: Springer, 2017.

[3] P. D. Walker, N. Zhang, and R. G. Longoria, "A model-based condition monitoring system for internal combustion engine wear using dynamic performance indicators," *Mechanical Systems and Signal Processing*, vol. 110, pp. 267–281, 2018. doi: 10.1016/j.ymssp.2018.03.014.

[4] S. Singh, A. Rehman, and D. Kumar, "Condition monitoring of IC engine using machine learning techniques: A review," *Engineering Failure Analysis*, vol. 142, p. 107714, 2023. doi: 10.1016/j.engfailanal.2022.107714.

[5] M. Zhang, H. Wang, and Q. Li, "Intelligent fault diagnosis of diesel engines based on vibration and acoustic signals using deep learning," *Applied Acoustics*, vol. 189, p. 108609, 2022. doi: 10.1016/j.apacoust.2022.108609.

[6] D. Marchenko and K. Matvyeyeva, "Study of wear resistance of cylindrical parts by electromechanical surface hardening," *Problems of Tribology*, vol. 29, no. 1(111), pp. 25–31, 2024. doi: 10.31891/2079-1372-2024-111-1-25-31.

[7] O. Lymar and D. Marchenko, "Prospects for the application of restoring electric arc coatings in the repair of machines and mechanisms," in *Proc. 2022 IEEE 4th Int. Conf. Modern Electrical and Energy Systems (MEES)*, 2022. doi: 10.1109/MEES58014.2022.10005709.

UDC 004

CONCEPTUAL DESIGN OF A BUS TICKET SALES SERVICE MODULE

Anastasiia Kylynnyk (Anastasiia.Kylynnyk@hneu.net)
Simon Kuznets Kharkiv National University of Economics (Ukraine)

The development of the digital economy requires process automation. The research focuses on the development of a bus ticket sales module, which includes database modelling, user interface and order/payment processing logic to improve the efficiency of transport companies.

The activities of modern Ukrainian society in a market economy are closely linked to the use of information systems and technologies. The development of the digital economy, particularly in the field of e-commerce, requires specialists to have knowledge of algorithmisation, programming, modelling and