ABSTRACT

Dissertation by Beibit Kansbaevich Kaliyev on "Development of a method and stand for testing turbochargers of agricultural machinery" submitted for the degree of Doctor of Philosophy (PhD) in specialty 6D072400 - Technological Machines and Equipment (by industry)

Relevance of the topic:

Modern trends in internal combustion engine development are aimed at increasing power, efficiency, and environmental friendliness while simultaneously reducing their size and weight. One effective approach is the use of turbocharging systems. However, in agricultural machinery, turbochargers operate under increased thermal and dynamic loads, high dust levels, and frequent changes in operating conditions. This leads to accelerated wear of components, especially bearings, and a reduced service life.

To improve the reliability and durability of turbochargers, it is necessary to improve diagnostic methods and develop test rigs that simulate real-world operating conditions.

Objective of the work:

Improving the reliability and trouble-free operation of turbochargers for internal combustion engines of agricultural machinery by developing a method and experimental rig for testing them and establishing patterns of change in their parameters in various operating modes.

Research objectives

Conduct an analysis of the relationships between turbocharger performance indicators and existing diagnostic methods;

Establish patterns of turbocharger parameter changes during typical gas turbine supercharging system malfunctions;

Develop a research rig to enable experimental studies of turbocharger operating parameters under various test conditions;

Investigate the temperature characteristics of the turbocharger bearing assembly.

Object of study:

The process of supplying oil to the turbocharger bearing assembly.

Subject of research:

Patterns of change in lubrication parameters and dynamics of the turbocharger rotor under various operating conditions.

Scientific novelty

Analytical relationships were obtained for assessing the maximum operating parameters of a turbocharger.

The influence of oil pressure and temperature on the turbocharger rotor run-down time was determined.

Experiments have proven that the run-down time can serve as a diagnostic indicator of the unit's technical condition.

A method for assessing the condition of a turbocharger on a laboratory bench was developed, enabling the simulation of real operating conditions.

Practical significance

The practical significance of this work lies in the development and implementation of a set of technical and methodological solutions aimed at improving the reliability and uptime of internal combustion engine turbochargers.

A design solution and a circuit diagram for connecting the turbocharger to a test bench were developed, enabling the simulation of real operating conditions and experimental studies of bearing lubrication processes (Utility Model Patent RK No. 6207 dated April 9, 2021).

A diagnostic rig has been developed and tested that allows for determining the technical condition of a turbocharger without disassembling it, significantly reducing the labor intensity and duration of testing. The developed method for assessing the condition of the turbocharger and the proposed diagnostic scheme during operation ensure reliable monitoring and the ability to analyze the impact of engine parameters on turbocharger performance.

The results of the study have been implemented into the production process and practical operation of agricultural energy equipment, confirming their practical effectiveness and the possibility of using them in real operating conditions.

Testing the work. The research results were tested during research internships at the South Ural State Agrarian University, at meetings of the Academic Council of the A. Baitursynov Kostanay Regional University, and presented at international and national conferences (Baitursynov Readings, etc.).

Publications:

1. The development of a method for diagnosing internal combustion engines based on acceleration and rundown characteristics / A. Gritsenko, V. Shepelev, A. Burzev, B. K. Kaliyev // FME Transactions. – 2024. – Vol. 52, No. 1. – P. 147-156. – DOI https://doi.org/10.5937/fme2401147g

2. Alexander V. Gritsenko, Vladimir D. Shepelev, Beibit K. Kaliyev, Studying the Temperature Characteristics of Oil at the Outlet From the K27-145 Turbocharger Rotor Bearing, Tribology in Industry, vol. 44, no. 4, pp. 608-624, 2022, https://doi.org/10.24874/ti.1318.06.22.10

3. Shepelev, V., Gritsenko, A., Vorobyev, A., Kaliyev, B., Fadina, O. (2023). Increasing the Robustness of Modern Turbocharging Systems Using a Hydraulic Accumulator and Oil Circulation. In: Radionov, A.A., Gasiyarov, V.R. (eds) Proceedings of the 9th International Conference on Industrial Engineering. ICIE 2023. Lecture Notes in Mechanical Engineering. Springer, Cham. https://doi.org/10.1007/978-3-031-38126-3_36

4. The Development of Methodological Techniques and an Algorithm for Diagnosing Modern Intake Systems for Internal Combustion Eng FME Transactions / A.S. Balyasnikov, A. Gritsenko, V. Shepelev, B.K.Kaliyev, N. Kostyuchenkov, O. Fadina // FME Transactions. – 2022 - Vol. 50, No. 4. – P. 302-312, ISSN: 1451-2092 DOI:10.5937/fme2201302B

5. A. Gritsenko, F. Grakov, V. Shepelev, D. Nevolin and B. Kaliyev, "Justification of the Parameters for an Autonomous Lubrication System to Supply

Turbocharger Rotor Bearings in Negative Temperatures Conditions," 2022 International Conference on Engineering Management of Communication and Technology (EMCTECH), 2022, pp. 1-5, https://doi.org/10.1109/EMCTECH55220.2022.9934081

6. Kaliyev, B. K. Studying Surge Phenomena by Improving the Construction of a Turbocharger Testing Bench / B. K. Kaliyev, A. V. Gritsenko, V. D. Shepelev // IOP Conference Series: Earth and Environmental Science, Vladivostok, 06–09.10.2020. - Vladivostok, 2021. - P. 032056. - https://doi.org/10.1088/1755-1315/666/3/032056

Articles in publications recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan

7. Isintaev T. I. Study of surge by improving the design of a test rig for agricultural turbochargers / T. I. Isintaev, B. K. Kaliyev, A. M. Plaksin [et al.] // AIC of Russia. - 2020. - Vol. 27. - No. 4. - Pp. 642-648. https://elibrary.ru/item.asp?id=44267415

8. Kaliev B.K. Burtsev // D. Serikbaev atyndagi ShҚTU khabarshysy. – 2020. – No. 1. – P. 142-148. – https://doi.org/10.51885/15614212_2020_1_142

9. Gritsenko, A. V. Study of turbochargers of agricultural tractor diesel engines on a stationary stand with independent oil supply / A. V. Gritsenko, A. V. Starunov, A. A. Gorbachev, A. Yu. Burtsev, B. K. Kaliyev // Proceedings of the International Scientific and Practical Conference of the Institute of Agricultural Engineering, Chelyabinsk, November 30 – December 4, 2020 / Edited by N. S. Nizamutdinova. - Chelyabinsk: South Ural State Agrarian University, 2020. - P. 239-244. ISBN 978-5-88156-862-7

10. Isintaev, T. I. Conclusions of an experimental study of the stalling of the turbocharger rotor of an internal combustion engine / T. I. Isintaev, B. K. Kaliyev, A. V. Gritsenko // “Baitursynov readings - 2020: Materials of the international scientific and practical conference on April 24, 2020. - Kostanay: Kostanay State University named after A. Baitursynov, 2020. P. 288-292. ISBN 978-601-7597-76-4

11. Kaliyev, B. K. Methods for in-place diagnostics of turbochargers of agricultural machinery / B. K. Kaliyev, A. A. Gorbachev, T. I. Isintayev, A. V. Gritsenko // Innovative scientific research in the modern world: Collection of articles based on the materials of the international scientific and practical conference, Ufa, May 23, 2019. - Ufa: Limited Liability Company "Scientific Publishing Center" Vestnik Nauki ", 2019. - P. 131-139.

12. Kaliyev, B. K. Analysis of failures of pressurization systems of automotive internal combustion engines / B. K. Kaliyev, T. I. Isintaev, A. V. Gritsenko, A. Yu. Burtsev // Baitursynov readings - 2019, Kostanay, April 26, 2019. – Kostanay: Kostanay State University named after. A. Baitursynova, 2019. – P. 385-390. ISBN 978-601-7985-38-7

13. Gritsenko, A. V. Influence of various factors on the stability of rotation of the rotor of an internal combustion engine turbocharger / A. V. Gritsenko, T. I. Isintayev, B. K. Kaliyev // Baitursynov Readings - 2018: Proceedings of the

international scientific and practical conference, Kostanay, April 18-19, 2018. - Kostanay: Kostanay State University named after A. Baitursynov, 2018. - P. 165-170. ISBN 978-601-7955-21-2

14. Utility Model Patent No. 6207, National Institute of Intellectual Property, Nur-Sultan, Kazakhstan / Internal Combustion Engine Turbocharger No. 2021/0352.2: Published July 2, 2021 / B. K. Kaliyev, T. I. Isintayev, A. V. Gritsenko, A. Yu. Burtsev. https://kazpatent.kz/kk

At least 14 scientific papers have been published on the topic of the dissertation, including articles in journals included in the lists, the Scopus/Web of Science database recommended by the Committee on Quality Assurance of Science, and the proceedings of international conferences. The publication topics cover issues of turbocharger rotor rotation stability, a review of turbocharger failure diagnostic methods, analysis of braking parameters during engine stalls, diagnostic methods for internal combustion engine lubrication and fuel systems, rig design development, and evaluation of turbocharger operational reliability.

Keywords: turbocharger, diagnostics, coasting, agricultural machinery, test bench, reliability, supercharging, technical condition.

Structure and scope of the work. The dissertation consists of an introduction, five chapters, a conclusion, a list of references, and appendices. The total length of the work is 139 pages, with 68 figures and 9 tables, and 112 references.