ANNOTATION

of the dissertation by Tatyana Leonidovna Lub
on the topic "Investigation of the Accuracy of Rotary Machining Using a Tool with a Self-Rotating Cutting Edge",
submitted for the degree of Doctor of Philosophy (PhD)
under the educational program 8D07101 – Mechanical Engineering.

Relevance of the Research. The modern development of mechanical engineering is characterized by the rapid integration of digital and automated technologies, increasing requirements for the accuracy and quality of manufactured products, and the need to reduce production costs. One of the key directions of technological progress is the improvement of machining processes, which remain the principal means of producing high-precision surfaces of machine components.

The efficiency of machining is largely determined by the condition of the cutting tool. Rapid wear of the cutting edge reduces form accuracy and leads to higher production costs. Therefore, improving tool life and ensuring the stability of the cutting process remains a pressing challenge for contemporary metalworking.

One promising direction is rotary machining, in which the cutting tool or its elements perform an additional rotational motion. This motion enables more uniform wear distribution, reduces thermal loads, and improves the accuracy and quality of the machined surface.

Of particular interest are tools with a self-rotating cutting edge, where the rotation of the insert occurs due to friction and cutting forces without an external drive. This solution ensures continuous renewal of the cutting zone, reduces uneven wear, and increases machining accuracy.

Despite the evident advantages, the industrial use of self-rotating tools remains limited due to insufficient knowledge of the cutting process patterns. Broad implementation of such tools requires theoretical and experimental studies aimed at identifying the factors ensuring stability and high accuracy of rotary machining.

The research topic has substantial practical significance and aligns with the priority areas of the Comprehensive Plan for the Development of the Mechanical Engineering Industry of the Republic of Kazakhstan for 2024–2028, the State Program of Industrial and Innovative Development (SPIID-3) for 2025–2029, and the strategic goals of "Kazakhstan-2050," which emphasize the development of high-tech production and the introduction of domestic innovative solutions.

Thus, the study of rotary machining accuracy using a tool with a self-rotating cutting edge represents a timely scientific task aimed at enhancing the efficiency, quality, and stability of machining processes.

Object of the research – the process of rotary machining using a tool with a self-rotating cutting edge.

Subject of the research – the patterns governing the influence of the structural and technological parameters of a self-rotating tool on the form accuracy and the quality of the machined surface.

Purpose of the work – to study the influence of a self-rotating cutting edge on the accuracy of rotary machining, as well as to develop recommendations for optimizing the design parameters and cutting modes in order to ensure high accuracy and quality of machined surfaces.

Research objectives:

- to analyze existing methods of turning and rotary machining and to determine the patterns of their influence on the form accuracy and surface quality of machine components;
- to develop a design of a new tipless rotary turning tool with a self-rotating cutting edge and chipbreaker, and to justify the rational selection of its main geometric parameters;
- to develop a methodology for assessing the accuracy of rotary machining using self-rotating tools, taking into account the geometric, kinematic, force, and thermal factors of the cutting process;
- to perform computer modeling of the rotary cutting process using finite element analysis (CAE) to determine stress and strain fields, as well as to evaluate the influence of structural and technological parameters on machining accuracy and stability of self-rotation;
- to conduct experimental studies of the influence of cutting parameters and structural features of the developed tool on form accuracy, surface layer quality, and tool life;
- to evaluate the techno-economic efficiency of the developed rotary tool in comparison with a conventional turning tool during machining of typical components;
- to develop practical recommendations for selecting the design parameters and cutting modes of self-rotating rotary tools for precision machining of machine component surfaces.

Scientific novelty:

- for the first time, a method has been developed for evaluating the accuracy of rotary machining, taking into account the self-rotation of the cutting edge, based on modeling kinematic, power and thermal characteristics, which makes it possible to predict roughness, shaping accuracy and process stability depending on tool parameters and cutting modes;
- for the first time, wear modeling using the Monte Carlo method and three-dimensional CAE modeling of rotary cutting were performed. The simulations showed that the application of a rotary scheme with a bearing assembly reduces the maximum stresses σ_{max} by a factor of 9–12.
- experimental studies of the effect of feed, angle λ and cutting speed were carried out, it was found that at s = 0.1–0.2 mm/rpm and λ = 45°, roughness in the range of Ra 1.25...1.6 microns, accuracy of IT6–IT8 and an increase in tool durability of 8-12 times compared with traditional turning tools are provided;
- recommendations for selecting rotary machining parameters have been developed, enabling a reduction of form errors by up to 40% and providing more uniform wear of the cutting edge without the use of active cooling.

New structural solutions have been proposed and implemented for a tipless

rotary turning tool with a self-rotating insert and an integrated chipbreaker, ensuring stable insert rotation and uniform wear of the cutting edge. The novelty of the technical solutions obtained in the research is confirmed by an invention patent of the Republic of Kazakhstan No. 36087 dated 10.02.2023.

Reliability of the scientific results:

- the research is based on the fundamental principles of cutting theory and manufacturing engineering, the mechanics of deformable solids, the theory of elasticity and plasticity, as well as modern concepts describing the behavior of the "machine–tool–workpiece" system;
- the finite element method implemented in CAE systems was applied for numerical computer modeling of the cutting process and for quantitative evaluation of machining accuracy parameters;
- multifactor experimental studies were conducted under controlled cutting conditions and controlled states of the "machine–tool–workpiece" system, which confirms the reproducibility and reliability of the obtained data;
- experimental results were compared with the developed theoretical models and analytical calculations, demonstrating satisfactory agreement within measurement error limits;
- the obtained data were verified through comparison with results from previously published research in this field.

Practical significance and implementation of the results.

The practical value of the research lies in the possibility of implementing the obtained results in industrial practice, which will improve the dimensional accuracy of components, enhance the quality of machined surfaces, reduce tooling costs by doubling the service life of the cutting tool, and increase the overall efficiency of the technological process.

The findings of the study have been introduced into the educational process of Bauman Moscow State Technical University and Toraighyrov University, and are also utilized by the Association of Machine Builders of Pavlodar Region.

Main propositions submitted for defense:

- structural solutions for a tipless rotary turning tool with an integrated chipbreaker, which eliminate load concentration at the tool tip, stabilize the motion of the cutting edge, and ensure uniform thermal wear;
- finite element (CAE) simulation results confirming the reduction of stresses along the cutting edge, the numerical prediction of wear distribution, and the analysis of the influence of technological parameters on the assessment of self-rotation stability under various cutting conditions;
- results of experimental studies on the influence of cutting conditions and tool design parameters on the accuracy and surface roughness of machined components.

Approbation of the work.

The main findings of the dissertation have been presented in the article «Analysis of Rotary Cutter Structure» published in Russian Engineering Research, No. 42 (Suppl. 1), pp. 70–73 (2022), indexed in Scopus (Mechanical Engineering, 34th percentile); in three articles recommended by the Committee for Quality

Assurance in the Sphere of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan; in one invention patent; one collective monograph; two educational manuals; one conference abstract in a Scopus-indexed conference (16th percentile); and seven abstracts presented at national and international scientific and practical conferences.

The dissertation was carried out within the framework of:

- grant funding for fundamental and applied research projects for young scientists for 2021–2023 under project AP09058231 “Research and Design of Resource- and Energy-Saving Cutting Tools”;

- grant funding for scientific and/or scientific-technical projects for 2023–2025 under project AP19678887 “Investigation of Tribotechnical Characteristics of Resource- and Energy-Saving Cutting Tools”;

- program-targeted funding for scientific and/or scientific-technical programs for 2024–2026 under project IRN BR24993003 “Development of a Set of Measures for Tooling Support of Processing Industries of the Republic of Kazakhstan.”

The dissertation was fully presented and approved at the Scientific and Technical Council of the Faculty of Engineering of Toraighyrov University.

Publications. The main results of the dissertation were presented and discussed at various international conferences and were published in 18 scientific works, including:

- 3 articles in journals recommended by the Committee for Quality Assurance in the Sphere of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan:

1) Т.Л. Луб, Ж.К. Мусина, И.А. Шумейко, С.И. Деревягин, А.А. Ткачук. Математическое моделирование процесса износа при ротационной обработке инструментом с самовращающейся кромкой / Science and Technology of Kazakhstan, No. 1, 2025. - PP.128-142 (Russian);

2) Т.Л. Луб, А.Ж. Касенов, Ж.К. Мусина, , А.С. Янюшкин, Л.Р. Мусина. Обоснование геометрических параметров режущей пластины ротационного безвершинного поворотного токарного резца // Science and Technology of Kazakhstan, No. 2, 2024. - PP. 106-111 (Russian);

3) T.L. Lub, Zh. Kassenov, Zh. K. Mussina, A. S. Yanushkin, R. B. Kussainov. The effect of the design of a rotary peakless turning tool with chipbreaker on the surface roughness / Science and Technology of Kazakhstan, No. 1, 2024. – PP. 39-49.

- 2 articles in international peer-reviewed journals with a non-zero impact factor and indexed in the Scopus database (percentile not less than 16):

1) T.L. Lub, A. Zh. Kassenov , Zh. K. Mussina, A. S. Yanyushkin, K. K. Abishev. Peakless Rotary Cutter Design for Finish Turning // Conference paper, Lecture Notes in Mechanical Engineering (LNME) №42, Journal's ISSN: printed: 1068-798X, electronic: 1934-8088, Russian Federation, 2023. – PP. 915-924; Scopus percentile: 38.

2) T.L. Lub, A. Zh. Kassenov , Zh. K. Mussina, G. T. Itybaeva, A. S. Yanyushkin. Analysis of Rotary Cutter Structure// Conference paper, Lecture

Notes in Mechanical Engineering (LNME), Journal ISSN: printed: 2195-4356, Electronic: 2195-4364, Germany, 2022. – PP. 70-73, Scopus percentile: 16.

- domestic and international scientific and practical conferences:

1) Т.Л. Луб, С.В. Грубый. Геометрические параметры и составляющие силы для пластины режущей круглой формы // All-Russian Scientific and Technical Conference "Student Scientific Spring : Machine–building technologies" : conference proceedings April 4-8, 2022. - PP.1-2, Moscow : Bauman Moscow State Technical University. – Moscow : KvantorForm LLC, 2022. URL: https://studvesna.ru?go=articles&id=3330 (Russian);

2) А.С. Янюшкин, Т.Л. Луб А.Ж. Касенов Инновационные технологии в машиностроении : сборник трудов XIII Международной научно-практической конференции // Yurginsky Institute of Technology. Tomsk : Publishing House of Tomsk Polytechnic University, 2022. 140 p. ISBN 978-5-4387-1074-5. PP.17-19. URL: https://earchive.tpu.ru/handle/11683/72725 (Russian);

3) Т.Л. Луб, А.Ж. Касенов, Д.С. Жолжаксинов. Обзор методов мониторинга и прогнозирования износа самовращающихся резцов в условиях интеллектуальной обработки/ Modern Science: Development Trends, International Conference, Republic of Tajikistan, Dushanbe. Mir Nauki Scientific Publishing Center, 2025. PP. 17-22. URL: https://elibrary.ru/item.asp?id=82329037&pff=1 (Russian);

4) Т.Л. Луб, Д.А. Искакова, А.Ж. Таскарина SWOT-анализ конструкции ротационного безвершинного поворотного резца со стружколомом/ New Approaches in Science and Education, Mir Nauki Scientific Publishing Center, Kazakhstan, 2024. PP. 10-19 .

URL:https://www.elibrary.ru/item.asp?id=80319790&pff=1 (Russian)

- 1 patent of the Republic of Kazakhstan for an invention: Патент на изобретение № 36087, 10.02.2023 г. Ротационный безвершинный поворотный токарный резец со стружколомом // Application registration number: 2021/0494.1. / A.Zh. Kasenov, Zh.K. Musina, G.T. Itybayeva, K.K. Abishev, D.A. Iskakova, A.S. Yanushkin

Structure and volume of the dissertation. The dissertation consists of an introduction, five chapters, conclusions, a final summary, and a list of references comprising 192 sources. The main text is presented on 198 pages (excluding appendices) and includes 96 figures, 35 tables, and 23 appendices.