ABSTRACT

of the dissertation for the degree of Doctor of Philosophy (PhD) in the field of study: 8D071 «Engineering and Engineering affairs», GEP D103 «Mechanics and metal working», educational program: 8D07105 «Mechanical Engineering»

Gulim Magauiyanovna Tussupbekova

Dissertation topic: **«Development of a method for increasing the wear resistance of metal-cutting tools»**

The relevance of research. Mechanical engineering remains one of the key manufacturing industries in industrialized countries. In Kazakhstan, the development of the sector is considered as a priority of the state industrial policy and a tool for strengthening economic sustainability.

Currently, state support measures are continuing in the country at both the republican and local executive levels within the framework of the "Comprehensive Plan for the development of the machine-building industry of the Republic of Kazakhstan (RK) for 2024-2028, approved in 2023."

The efficiency of machine-building production is determined by many factors, among which metal-cutting tools occupy an important place. Most of the tool failures (up to 75%) occur due to wear of the cutting edges.

This is especially true in the processing of difficult-to-process materials, which is widely used in all industries, since for these materials the labor intensity of processing the workpiece is commensurate with the resource of the tool.

The global integration of domestic and foreign manufacturers has led to an increase in the use of foreign machinery in the domestic industry. In this regard, new materials that differ in chemical composition and mechanical properties are increasingly being used in industries. The mechanical processing of such materials also negatively affects the consumption of metal cutting tools. Since errors made when assigning cutting modes and choosing the material of the cutting part of the tool, due to the lack of appropriate recommendations in available reference sources, lead to premature wear or breakage of the cutting edge.

The situation is further aggravated by the fact that for countries (including Kazakhstan) that do not have their own tool industries, metal-cutting tools have to be purchased at a high (inflated) cost from foreign manufacturers. All this leads to an increase in the cost of a mechanical operation, and ultimately an increase in the cost of manufactured products.

In this regard, the problem of increasing the durability (service life) of cutting tools when processing difficult-to-process materials is one of the major practical problems of modern mechanical engineering.

The solution to this problem may be to develop a method for increasing the wear resistance of cutting tools that is versatile, easily accessible, and at the same time provides high durability and wear resistance. This method is the method of pre-working cutting tools. It is known that pre-working as a method of increasing the durability and reliability of a tool is economically justified in relation to

expensive tools, the work of which involves high material and technical costs. However, the use of the pre-run-in method has not been studied to increase the wear resistance of cutting tools operating by copying, in particular modular disk cutters. The results of the research performed in the conditions of domestic machine-building industries have shown that disk modular milling cutters are mainly used in the processing of tooth cavities. It was found that modular disk cutters do not withstand the period of durability and fail prematurely due to wear of the cutting edge, discoloration and chipping.

In this regard, scientific research aimed at developing a way to increase the wear resistance of gear-cutting tools operating by copying, in particular modular disk cutters, is **an urgent task**.

The purpose of the work is to extend the durability of tooth-cutting tools by increasing their wear resistance.

Object of research: methods and technologies for increasing the wear resistance of metal-cutting tools.

Subject of the study: patterns of influence of the modes of the method of pre-working of a gear-cutting tool on the formation of a wear-resistant working surface

Research methods: to conduct the research, the following methods were used: analysis of existing methods and methods for increasing the wear resistance of metal-cutting tools, experimental research, planning and processing of results, metallographic research, computer modeling of the process of pre-working a gear-cutting tool.

Research objectives:

1. Investigation of the state of the problem of increasing the wear resistance of metal-cutting tools. Analysis of existing methods for increasing the wear resistance of metal-cutting tools and investigation of the causes of wear.
2. Theoretical study of the pre-working process of metal-cutting tools.
3. Development of a resource-saving method for increasing the wear resistance of metal-cutting tools, in particular, for processing teeth. Organization and conduct of experimental studies on the preliminary running-in of a disk modular milling cutter.
4. Metallographic study of the structure of the cutting part of a disk modular milling cutter after preliminary running-in.
5. Computer simulation of the process of preliminary running-in of a disk modular milling cutter and investigation of the deformed state of stresses, as well as structural changes in it.
6. Calculation of economic efficiency from the use of a modular disk milling cutter with pre-running-in. Developing recommendations for production.

The scientific novelty of the work is as follows:

1. A resource-saving method has been developed to increase the wear resistance of metal-cutting tools by pre-working.
2. It was found that increasing the pre-running modes to S=60 mm/min, n=110 rpm, t=6min has a positive effect on increasing the durability of the tool.

3. For the first time, a simulation of the running-in process of a gear-cutting tool, a disk modular milling cutter was performed and it was found that after preliminary running-in, a secondary contact layer with a thickness of 0.41 mm is formed on the working surface of the tool.

Provisions to be defended:

1. A resource-saving way to increase the wear resistance of a gear-cutting tool by pre-running in.

2. The results of experimental studies on the preliminary running-in of a disk modular milling cutter.

3. The results of modeling the process of preliminary running-in of a disk modular milling cutter, carried out using the ANSYS WB program.

The validity and reliability of scientific statements, conclusions and results is confirmed by the correctness of the formulation of the research problem, the adequacy of theoretical and experimental research. The patent of the Republic of Kazakhstan (No. 9307) for a method of increasing the wear resistance of metal-cutting tools was obtained. The certificate of the Republic of Kazakhstan on the inclusion of information in the State List of Intellectual Property rights protected by Copyright on the methodology of a comprehensive study of increasing the wear resistance of a disk modular milling cutter by the method of pre-working (No. 72771) was obtained.

The practical significance lies in the development of:

- a resource-saving method of increasing the wear resistance of a gear-cutting tool by pre-working;
- methods of a comprehensive study of increasing the wear resistance of a disk modular milling cutter by the method of pre-working;
- recommendations for industrial implementation.

The author's personal contribution consists in setting tasks and developing research methods; organizing and conducting experimental studies on the pre-running of a modular disk milling cutter; determining optimal pre-running modes; modeling the process of pre-running a modular disk milling cutter.

The dissertation work is aimed at fulfilling the main objectives of the "Comprehensive Plan for the development of the machine-building industry of the Republic of Kazakhstan (RK) for 2024-2028". As well as the main results of the dissertation, they were introduced into the production of RAPID Mechanical Plant LLP (Astana, 2025).

Approbation of the work. The main provisions of the doctoral thesis were reported and discussed at the meetings of the Department of "Technological Machines and Equipment" of KazATIU named after S. Seifullin (2022-2026), as well as at international conferences:

- Scientific and practical International conference "Seifullin Readings – 18(2): "Science of the 21st Century – the Era of Transformation" (Astana, 2022);
- LXXX International Interdisciplinary Conference “Recent Scientific Research". Conference proceedings (USA, 2026).

Publications

According to the results of his doctoral dissertation, 10 papers were published in Russian, Kazakh and English, including: 2 articles in an international scientific publication, according to the Clarivate database or included in the Scopus database, 4 articles in publications recommended by the Committee for Quality Assurance in Education and Science of the Republic of Kazakhstan. The reports of the presented work were reviewed at 2 international conferences. Received 1 patent of the Republic of Kazakhstan for a utility model and 1 certificate of state registration of rights to an object of copyright.

The scope and structure of the work. The doctoral dissertation consists of an introduction, 5 chapters and a conclusion, set out on 102 pages of typewritten text, which are explained by 49 figures, 17 tables, a list of references from 98 titles, 3 appendices.

Conclusion

During the dissertation work, studies were conducted aimed at increasing the durability period of the disk modular milling cutter and the following results were achieved:

1. A resource-saving method has been developed to increase wear resistance by pre-running in metal-cutting tools, in particular, tools for dental treatment. As a result, an increase in running-in modes to a certain value (s = 60 mm/min; n = 110 rpm; t = 6 min) was found to have a positive effect on the durability of the tool. In this case, it was possible to increase the durability period of the tool to T = 155 minutes. It is also established that under optimal pre-working conditions of the tool, the best deformation and thermal conditions are provided for strengthening the cutting part of the tool.

2. After preliminary work-up, a metallographic study of the structure of the cutting part of the disk modular milling cutter was carried out. It is established here that in the process of phase transformation: part of the residual austenite passes into deformation martensite, and carbides are crushed and evenly distributed, and a secondarily reinforced structure is formed on the surface.

3. A computer simulation of the running-in process of a disk modular milling cutter and a study of the stress-strain state, as well as structural changes in it, was carried out. As a result, after running in, a reinforced layer with a thickness of 0.41 mm is formed on the cutting edge of the disk modular milling cutter.

4. The economic effect of using a modular disk milling cutter with pre-run-in showed 1,527,777 tenge.

5. The results of the dissertation research are recommended for inclusion in the production environment of “RAPID Mechanical Plant” LLP.