ANNOTATION

Meruert Amirkhanovna Berikbaeva's dissertation work
"Improving the Quality of the Internal Surface of Hydraulic Cylinders through Combined Processing",
submitted for the degree of Doctor of Philosophy (PhD)
specialty: 6D071200 - "Mechanical Engineering"

Relevance of the work.

The development of the engineering industry is one of the important indicators of the technological level of industry around the world. Mechanical engineering has an effective influence on the development of other related industries, providing employment to the majority of the population and the competitiveness of the economy of both regions and the state as a whole.

In Kazakhstan, as throughout the world, the development of the engineering industry plays an important role in economic growth. The development of mechanical engineering will increase productivity in a number of other industrial sectors and improve the technological and technical level of existing industrial organizations.

Modernization of existing enterprises with modern equipment, creation of new enterprises to produce competitive products of international standard, solution of issues to improve repair production, is fundamental for industrial engineering.

The development of modern domestic mechanical engineering and regional industrial enterprises implies the joint development of modern technologies in all areas of domestic science, as well as the training of qualified personnel at all levels of production.

When developing the dissertation, the task was set to resolve the issue of analysis and further development of technology and methodology for the manufacture of hydraulic power cylinders (power part), from industrial and scientific points of view.

An analysis of research by Kazakh scientists and foreign specialists in the field of hydraulics in mechanical engineering has shown that the development of technological solutions to improve and increase the operational properties of hydraulic cylinders in mechanized lifting devices using special finishing and strengthening methods is relevant and is determined by research and work in this direction .

The production of competitive equipment and units for industry is the main component of one of the technologically advanced sectors of heavy engineering - mining engineering.

The basis for developing the topic of this dissertation is the solution of technological problems in the manufacture of power hydraulic units of lifting and transport equipment used in railway transport during road repairs, using the method of combined surface treatment.

The constant growth of technological progress in the engineering industry, as well as an increase in labor productivity, sets a number of tasks for creating a material and technical base.

The solution to the set tasks, in order to achieve the goals, is carried out by introducing automated production processes (APP) into industrial complexes, applying modern developments in the field of this science and technology, and increasing the mechanization of work at enterprises. Despite their small dimensions, modern industrial machines are characterized by high energy consumption of structural elements. Definitely, one of these elements is a hydraulic power unit (hydraulic cylinder), which, due to its characteristic characteristics, is considered to be quite simple in design, as well as a fairly reliable device when implementing reciprocating motion, in comparison with standard or similar types of drives, for example, electric drives. Hydraulic drive is a converting equipment that is designed to move machines and elements of their mechanisms by compressing the working fluid and directing it into the system.

The development of technology for the repair and restoration of hydraulic cylinders using a combined processing method to improve the quality of the working surface is in demand and relevant.

The planned scientific and technical level of development and patent research is determined by the completeness of the literature review of the patent search on the problems of manufacturing, repair and restoration of hydraulic cylinders, the development and selection of research methods in this area, as well as the conduct and organization of the necessary experiments in the dissertation.

On the analytical basis of open sources on patents, the main effective methods for using new technological solutions for processing hydraulic cylinders, as well as the technologies and quality of production and repair of hydraulic cylinders are considered. The dissertation provides the results of a scientific analysis of the current state of the scientific and technical problem and patent research in the field of manufacturing hydraulic cylinders.

Hydraulic cylinders are an integral part of the mechanized industrial complex of various fields and areas. Hydraulic cylinders act as a supporting element when lifting the grate and ensure that it is held at a given height for the required time. Thus, justification and study of the process of producing holes with a combined tool with predictable properties allows us to determine the boundaries of the rational use of the tool being developed based on standard existing options.

As a result, increasing the reliability and durability of hydraulic cylinders for mechanized lifting devices and transport equipment by rationalizing the current design and improving the current technological process is an urgent task in the dissertation.

– Obtaining the inner surface of machined holes in parts of the “body of rotation” type that meet the requirements of increased wear resistance, which are used in

many machines and mechanisms operating in harsh conditions, is an urgent task of modern metalworking methods.

- Of particular scientific interest are methods and methods of surface plastic deformation, using prefabricated metal-cutting tools for processing the internal surface of cylindrical parts at the enterprise.
- Hydraulic cylinders are the main unit in the transmission and conversion of energy, the interfaces of which ensure the operability of technological devices; for this reason, high quality requirements are imposed on the working surfaces for the manufacture of parts.
- Breakdown or failure of hydraulic cylinders can be caused by an aggressive environment, structural and technological parameters. When changing structural parameters, the strength of the structural elements of the rack and hydraulic cylinder is not sufficiently ensured, which leads to destruction and deformation under the influence of loads. When changing technological parameters, the required wear resistance of the main working mating surfaces working in a friction pair is also insufficiently ensured by technological processes at the stage of manufacturing these parts on metal-cutting machines.

The purpose of the dissertation research is to develop an innovative technology for processing the inner surface of a hydraulic cylinder liner using a combined tool to improve its quality by reducing the surface roughness of the liner and increasing the hardness of the surface layer.

Object of study. Hydraulic cylinder for lifting and lowering elements of lifting and transport equipment systems for repair and construction work. The device operates in both light and severe conditions such as air dust, changes in ambient temperature, all conditions characteristic of different climatic zones.

Subject of study. A number of factors have a great influence on the reliability of hydraulic power cylinders and their service life.

The objectives of the research when performing research work are:

- performing an analysis of design features and establishing quality criteria for hydraulic cylinders used in mechanical engineering;
- to study the technological process of processing hydraulic cylinder liners to substantiate the dependencies connecting the parameters of the resulting surface with combined processing modes and design parameters of the tool;
- develop a computer model of a combined tool taking into account the optimal design parameters of its geometry and determine the maximum permissible deformations of the material structure to calculate the conditions of the prestressed state;
- to improve the technological process for the manufacture of a hydraulic cylinder liner using the developed tool for the strain-hardening method of processing the inner surface of the liner.

The research methods used in the work are based on the principles of basic sciences: tolerances and fits, mathematical statistics, mechanical engineering

technology, design fundamentals and parts of hydraulic machines, theories of elastic-plastic deformation.

Studies of the stress-strain state of a hydraulic cylinder using software products and complexes Solid Works, Deform and KOMPAS-3D were carried out on the basis of the computer modeling laboratory of the M. Kozybayev North Kazakhstan University.

The scientific novelty of the work lies in determining the relationship between operating conditions and accuracy parameters in the manufacture and repair of a hydraulic cylinder, which makes it possible to determine the necessary parameters of the technological process in the manufacture of the part.

- The relationships between the height of microroughnesses (Ra), parameters of the hardened layer (Рн) and the modes of the applied combined processing with optimal design parameters of the cutting tool were determined;
- A model of the process of combined processing of the inner surface of a hole has been developed, with a reasonable choice of processing modes: speed V, feed S and depth of cut, t;
- The thermal and power characteristics of a combined tool, oriented in the direction of the useful forces arising in the tool during the cutting process, have been determined.
- The optimal design and technological parameters of the technological process of processing the inner surface of the hydraulic cylinder liner using the developed combined tool have been substantiated.
- Based on the above, a standard methodology has been developed for designing combined tools for processing the inner surface of a hydraulic cylinder liner, as well as a method for processing the cylinder of hydraulic lifts, ensuring uniform operation in the friction pair of the liner and the piston of the hydraulic cylinder.

Scientific propositions of the thesis submitted for defense (scientific results):

- Justified optimal design and technological parameters describing the influence of technological modes of combined processing S, V, t on the change in roughness Ra and hardening of the surface layer of the hydraulic cylinder liner T.
- Developed design of a combined reamer for processing the internal surface of hydraulic cylinders, for which an innovative patent for a utility model of the Republic of Kazakhstan No. 7082 dated 01/12/2022 was received
- The developed algorithm for calculating the structural elements of a combined reamer makes it possible to produce a tool for given conditions, in accordance with the accuracy parameters of the part.
- Methodology for calculating prefabricated combined tools for machining holes.
- The improved technology for manufacturing the hydraulic cylinder liner reduces the number of technological operations by three and reduces the technological time spent by 1.2%, the number of cutting tools used is reduced to two.

Work's practical relevance.

- The use of a new technology for manufacturing a hydraulic cylinder liner using a combined tool increases the service life of the hydraulic cylinder by 12.3% by creating a hardened layer on the metal surface of the liner from 30 to 45 HRC microhardness and reducing roughness to Ra 0.32 microns;
- Reducing the cost of the liner by 2.8%, increasing the operating life of the hydraulic cylinder by 12.3% is ensured by the use of a new cylinder manufacturing technology with cutting processing and the method of surface plastic deformation;
- A combined development model has been developed using the Compass 3D, SolidWorks, Deform program, which allows one to establish the stress-strain state of the developed tool and identify local stresses to correct the obtained data.
- A technological process has been developed for creating the design of a combined tool for machining holes in hydraulic cylinders using a combined reamer;
- The results of the work are used in the educational process in the preparation of undergraduate students in the OP "Mechanical Engineering" at the North Kazakhstan University named after. M. Kozybaeva
- The results of the work are used in the educational process in the preparation of curricula for students in the specialty 6B07101 - "Mechanical Engineering" at the North Kazakhstan University named after. M. Kozybaeva;
- Based on the results of dissertation research, a design of a combined reamer was developed for processing the internal surface of hydraulic cylinders, for which an innovative patent for a utility model of the Republic of Kazakhstan No. 7082 dated January 12, 2022 was received.
- Reducing the cost of the liner by 2.8%, increasing the service life of the hydraulic cylinder by 12.3% is ensured by the use of a new cylinder manufacturing technology with cutting processing and the method of surface plastic deformation.
- The results of the work carried out can be used in mechanical engineering production, both as aids for writing theses by students of educational organizations, and for research work of bachelors and masters in the specialty "Mechanical Engineering".

Practical approval. The main results of the dissertation research were reported and discussed at: International scientific and practical conference "Kozybayev Readings – 2019: Spiritual modernization and development trends of scientific and educational space in the modern world" (Petropavlovsk, Kazakhstan, 2019); International scientific and practical conference "Saginov Readings - 2019: Integration of science, education and production - the basis for the implementation of the Nation's Plan" (Karaganda, 2019), International scientific review of the problems and prospects of modern science and education. LXVI International correspondence scientific and practical conference (Boston 2020).

Publications. The main results of the dissertation work were published in 12 printed works, including 3 articles in publications recommended by KOKSON Ministry of

Education and Science of the Republic of Kazakhstan; 6 publications in International conferences, of which 3 are foreign; 1 article in the Scopus database of indexed journals with a percentile of 44. An innovative patent for a utility model of the Republic of Kazakhstan No. 7082 dated January 12, 2022 was received.

Personal contribution of the author. The main results of theoretical and experimental studies were obtained by the author independently. In published works written in collaboration, the applicant plays a leading role in summarizing and analyzing the results obtained.

Structure and scope of work. The dissertation consists of an introduction, four sections and a conclusion, presented on 115 pages, contains 20 figures, 8 tables, 87 sources used and 4 appendices.

Research results. The main scientific and practical conclusions of the dissertation work are as follows:

- Based on the conducted research, it was established that using a new combined tool for processing internal cylindrical holes improves the quality of the working surface: an increase in the hardness of the surface layer from 30 HRC to 45 HRC, a decrease in roughness to Ra 0.32 microns.
- Experimental studies of the material and its properties acquired as a result of combined processing have shown:
    - strengthening of the surface layer of the treated hole is observed at a depth of 0.8...1.1 mm;
    - the hardness of the surface layer of the treated hole increased by 1.5 times.
- A model of the combined process of machining holes in cylinders was created, which establishes a correspondence between the geometric characteristics and physical and mechanical properties of the machined surface with the design parameters of the tool and processing modes.

Experimentally established:

- The height of the irregularities is directly proportional to the feed amount.
- The speed of combined processing does not have a significant impact on the quality of the surface layer, but is a limiting factor in heat generation.
- The thermal and power characteristics of the combined tool, oriented in the direction of the forces arising in the tool during the cutting process, have been determined.
- The developed computer model of combined development allows for effective tool design, taking into account the stressed areas of the cutting tool and the current cutting resistance forces.
- It was found that during combined processing, contact pressure, which does not lead to destruction, helps to reduce the roughness of the surface layer.
- The pre-processing roughness of the holes Ra0.8, which provides the next higher-quality processing of the hole to the value of Ra0.32 μm, can be obtained by a combined tool with a cutting part with an optimal leading angle of 6°;

– the radius of the deforming element of 5 mm will determine the degree of hardening and the quality of the surface layer.

Papers published on the topic of the dissertation.

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2. Berikbaeva M.A. Methods of abrasive processing of metal surfaces // NKSU im. M. Kozybaeva. Materials of the MNPK "Kozybayev Readings - 2019: Spiritual modernization and trends in the development of scientific and educational space in the modern world." 15.11. 2019, Petropavlovsk, pp. 61-65
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4. Berikbaeva M.A., Khairullin B.T., Mukhamadeyeva R.M. The study of methods for combined processing of deep holes of hydraulic cylinders // International Journal of Mechanics. Coatings. – 2020. - V 14. - P.177-184.- PP. 44 (Scopus)
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10. Berikbaeva M.A., Mukhamadeeva R.M., Kasymzhanova K.S. The use of combined tools when processing deep holes // KarTU im. A. Saginova “Proceedings of the University” Series mechanical engineering, metallurgy. Karaganda, 2023. - No. 2 (91) - P. 12-18
11. Mukhamadeeva R.M., Berikbaeva M.A. Combined reamer for processing the inner surface of hydraulic cylinders // Patent for utility model of the Republic of Kazakhstan No. 7082 dated January 12, 2022.

12. Berikbaeva M.A. Improving the quality of the internal surface of hydraulic cylinders through combined processing // Certificate of entry of information into the state register of rights to objects protected by copyright. No. 21471 of November 8, 2021. Type of copyright object: work of science.