ABSTRACT

thesis on the topic:

“Influence of stress-deformed state of surfaces at its quality indicators during the processing of cylindrical details by method of plastic deformation”

submitted for the degree Doctor of Philosophy (PhD)

by specialty 6D071200 – “Mechanical engineering”

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Relevance of the research

Engineering around the world is perceived as an indicator of the technological level of the national industry. This industry provides a multiplier effect for the development of related industries, greatly increases the employment of the population and thereby ensures the competitiveness of the economy as a whole.

Consequently, the growth of the economy of Kazakhstan should be accompanied by the outpacing growth of engineering. This will allow increasing the degree of mechanization at industrial enterprises and increasing labor productivity in the branches of the republic’s economy.

In accordance with the long-term priorities of the Strategy “Kazakhstan - 2050”, the State program of industrial-innovative development of the Republic of Kazakhstan for 2015–2019 (program) was developed, in implementation of the key direction “Accelerating the diversification of the economy” of the strategic development plan of the Republic of Kazakhstan until 2020 , the concept of entering Kazakhstan among the 30 developed countries of the world, as well as pursuing the instructions of the Head of State given at the XXVI plenary meeting of the Foreign Investors Council and the President of the Republic of Kazakhstan, within the framework of realization of the Message of President of Kazakhstan to people of Kazakhstan "Kazakhstan's way - 2050: common goal, common interests, common future" from January 17, 2014.

The program is aimed at modernizing existing enterprises with high-tech and modern equipment, creating new enterprises for the production of competitive products of international standard, for the development and cooperation of all existing machine-building domestic enterprises.

Development of domestic machine-building enterprises involves the parallel development of national science and training of qualified personnel. In this thesis, the task was set to solve the issue of developing the technology of making hydraulic equipment from a scientific and industrial point of view.

Hydraulic cylinders (hydraulic racks) are part of the modern mechanized complex of mining production. The hydraulic cylinders of the mechanized complex perform the function of the supporting element of the roof in the face and provide resistance to lowering the roof.

Hydraulic cylinders in mechanized roof supports are the most important component to ensure the safety of cleaning operations, and therefore, technical requirements are imposed on hydraulic cylinders.

The main causes of failure of the hydraulic cylinders (racks) are constructional and technological parameters. If in the first case it is not provided the required strength, which leads to deformation and fracture resistant under the influence of external loads, in the second case does not provide the desired wear resistance surface manufacturing process details.

Therefore, increasing the reliability and durability of the hydraulic cylinders mechanized supports by improving the design and development of the new process is an actual problem.

Production of high-quality and competitive equipment and machinery for the mining industry is the main aspect, one of the priority sectors of mechanical engineering, mining engineering.

The basis and initial data for the development of the topic

The basis for the development of the topic of dissertation work is the creation of technological solutions for the manufacture and hardening of hydraulic cylinders using the methods of surface plastic deformation for mechanized supports used in the mining industry.

As initial data for the development of the research topic, we selected: mechanized support, used at one of the largest potassium deposits in the world, JSC “Belaruskalii” (Soligorsk, Republic of Belarus) and master's results applied at the JSC “Almaty machine-building plant named after S.M. Kirov” (Almaty, Republic of Kazakhstan) in the manufacture of cylinders (for hydraulic train drives) with using plastic deformation methods.

Justification of the need for research

Further steady growth of technical progress in mechanical engineering and increase in labor productivity is conditioned by the tasks of creating a material and technical base. To solve these problems, it is necessary to introduce automated production processes into industry, to apply the latest developments and achievements of science and technology, as well as to increase the rate of mechanization of work. With relatively small dimensions, modern machines are notable for their high energy consumption. One of such devices is a hydraulic drive, in its qualities it turned out to be a simple and reliable means for obtaining reciprocating and rotational motion, in comparison with other types of drives. A hydraulic drive is a device designed to drive machinery and mechanisms through a stream of compressed working fluid.

The State Program of Industrial-Innovative Development of the Republic of Kazakhstan for 2015–2019 (Presidential Decree of the Republic of Kazakhstan No. 874 of August 1, 2014) said, that one of the priority sectors of engineering is the production of machinery and equipment for the mining industry. In the sector of the production of machinery and equipment for the mining industry, the main issue is the production of high-quality and competitive mining equipment. In this regard, the development of technology for manufacturing hydraulic cylinders with the use of thermal nozzle of reinforcing rings and the use of plastic deformation processing to increase the life of their work is collect and relevant.

Information about planned scientific and technical level of development, **patent research and conclusions from them** are determined by the completeness of the patent search conducted in the literature review on the problem of designing and manufacturing hydraulic cylinders, the development and selection of modern research methods, system organization and experiments.

Based on the analysis of available patent information, the efficiency of using new technical and technological solutions for improving the technology and quality of production of hydraulic cylinders is considered. The thesis presents the results of a scientific analysis of the current state of scientific and technical problems and patent research in the field of manufacturing hydraulic cylinders.

Information about the metrological support of the dissertation

Research by theme of the thesis were conducted on the basis of JSC "Almaty machine-building plant named after SM. Kirov "(Almaty, Republic of Kazakhstan) and on the basis of UME " NIVA"(Soligorsk, Republic of Belarus) during the overseas internship.

Roughness measurements were made on the basis of UME "NIVA" (Soligorsk, Republic of Belarus), the device for determining the roughness - Surftest SJ-210 profilometer, manufactured by Mitutoyo (Japan).

Hardness measurements were made on the basis of UME "NIVA" (Soligorsk, Republic of Belarus), the device for determining the hardness is a portable dynamic hardness tester "Constanta TD", manufactured by JSC «KONSTANTA» (Russia).

Purpose of research

Increasing the life of the hydraulic cylinder by introducing a new technology for manufacturing a cylinder with a thermal packing of rings, followed by processing by method of plastic deformation.

Object of research

Hydraulic cylinder of mechanized support for the mining industry, operated in harsh conditions. Under harsh conditions is meant mine methane - air atmosphere with high humidity and dust in the air, aggressive environment, temperature changes, that is, conditions characteristic of the mining industry.

Subject of research

Constructive and technological factors affecting the reliability and durability of the hydraulic cylinder of mechanized support.

Research objectives, their place in the implementation of research work in general

– to perform an analysis of the design features of hydraulic cylinders used in mining engineering;

– calculate the stress-strain state of the hydraulic cylinder under the action of reinforcing rings, to establish their influence;

– to develop a computer model of a hydraulic cylinder with considering the design parameters and to determine deformations for the conditions of a pre-stressed state (reinforcing rings);

– to develop the technological process of manufacturing a hydraulic cylinder with considering the deformation under pressure of the working fluid with the use of finishing-strengthening method of processing.

Each individual task presented above and solved in the present dissertation work is logically associated with other tasks among themselves and aimed at the achievement of the objectives of the work.

Methodological base of research

Research methods used in the work are based on the provisions of such sciences as engineering technology, mathematical statistics, tolerances and landings, the fundamentals of designing hydraulic machine parts and the theory of elastic-plastic deformation.

Research of the stress-deformed state of a hydraulic cylinder using the Solid Works software systems were conducted on the basis of the computer modeling laboratory of the Rzeszow Polytechnic University named after I. Lukasievich (Rzeszow, Poland) during a foreign internship.

Scientific novelty of the work

– an increase in the service life of hydraulic cylinders and a decrease in the leakage of the working fluid at high pressures is ensured by the creation of compressive thermal stresses in the body material with a hot nozzle of casing rings heated to a temperature of 250 ° C;

– an analytical dependence of the contact pressure arising in the body of the hydraulic cylinder during the thermal fit of the casing rings and the formation of an adjustable interference fit on their geometric dimensions and the ratio of the length of the seating surface to its diameter was established, and the step of the pressed casing rings and their width depends on the internal pressure of the hydraulic system and are in proportions 1: 2; 1: 4; 1: 8 and so on to the last;

– assessment of the stress-strain state of the hydraulic cylinder with casing rings was carried out using the Solid Works software package, it was found to reduce stresses in the cylinder body by 1.5 times;

– the application of new technology for the manufacture of a hydraulic cylinder with a thermal nozzle by casing rings and subsequent processing by plastic deformation increases the service life of the hydraulic cylinder.

Provisions for the defense

– a hot nozzle of casing rings evenly distributes compressive stresses in the material of the cylinder body, allows to increase the service life and reduce leakage of the working fluid at high work pressures;

– the developed model of the hydraulic cylinder using the Solid Works program allows you to set the stress-strain state of the hydraulic cylinder and identify local stresses;

– the increase in the working life of the hydraulic cylinder is ensured by the use of new technology for manufacturing a cylinder with a thermal nozzle of casing rings with subsequent processing by plastic deformation method, which allows to reduce deformation parameters and reduce normal loads;

– increasing the wear resistance and tightness of the hydraulic cylinder by correcting roughness deviations at the stage of preliminary machining by applying the plastic deformation method allows improving the cleanliness of the inner surface and increasing the hardness of the metal surface layer to 40-45 Rockwell units.

The practical significance of the work

– design documentation has been developed for the manufacture cylinders of hydraulic racks, taking into account design features that provide increased reliability and efficiency of work;

– developed technological process of manufacturing a hydraulic cylinder with the use of finishing-strengthening method of processing and thermal nozzle of reinforcing rings;

– the results of the work are used at JSC "Almaty Machine-Building Plant named after S.M. Kirov "in the design and development of technological processes in the manufacture of thin-walled shells;

– the developed technological solution for manufacturing and hardening of cylinders of hydraulic struts was adopted for use in the UME "NIVA" (Soligorsk, Republic of Belarus) in the design of mechanized roof supports and the development of technological processes for their manufacture;

– scientific results are used in the educational process of the Kazakh National Research Technical University named after K.I. Satpaev when preparing students for the specialty 5B071200 – "Mechanical Engineering";

– an innovative patent No. 30469 dated October 15, 2015 has been received for the design of a hydraulic cylinder of mechanized supports by the author of the dissertation work.

Also, the results of the work can be used in various areas of engineering production and as additional manuals for writing theses and dissertations for bachelors and undergraduates of the specialty "Mechanical Engineering".

Approbation of the work

The main provisions and results of the work were reported at the international conference "Assembly Connections, Designs and Technologies in Mechanical Engineering" (Poland, Rzeszow Polytechnic University, 2013); at the III International Scientific and Practical Conference "Fundamental and Applied Sciences Today" (North Charleston, USA, 2014); at the international scientific and practical conference "Innovative technologies, equipment and materials in mechanical engineering" (Almaty, KazNTU named after K.I. Satpaev, 2012); at the international scientific and practical conference "Problems of innovative development of the oil and gas industry", (Almaty, KBTU, 2013); at the international scientific and practical conference "Training of Engineers in the Context of Global Challenges of the 21st Century" (Almaty, KazNTU named after K.I. Satpaev, 2013);

Publications

The main results of the thesis were published in 7 publications, including 3 papers in scientific publications from list of the Committee for Control of Education and Science of MES RK; 1 papers in peer-reviewed journals, indexed in Scopus database; 3 papers in international conference proceedings, including 1 - in foreign conference.

Structure and scope of work

The thesis consists of an introduction, four sections and a conclusion set out on 159 pages, contains 54 figures, 9 tables, 141 sources used and 11 applications.