ABSTRACT

of the dissertation for the degree of Doctor of Philosophy (PhD) on specialty 6D071200 - "Mechanical Engineering"

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“Scientific Substantiation of the Production Technology of Low-frequency Hydraulic Power Pulse Systems”

Relevance of the study. In the State Program of Industrial and Innovative Development for 2015-2019, the emphasis on priority sectors of the manufacturing industry was strengthened. In particular, it is noted that mechanical engineering is the basic branch of the country's economy, closely interconnected with the leading sectors of the economy and ensuring their sustainable functioning, filling the consumer market, and is the basis for the development of the technological core of industry.

The most important specific indicators of the gross domestic product of the country (material intensity, energy intensity, etc.), labor productivity in other sectors of the national economy, the level of environmental safety of industrial production and the defense capability of the state depend on the level of development of mechanical engineering.

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 relations of all existing domestic mechanical engineering enterprises.

The program also provides for continuous improvement of product quality based on the development of the most effective, scientific, technical and technological developments aimed at creating new types of machines, technologies and equipment.

In recent years, a relatively new direction in technology has begun to develop more and more widely: hydraulic impact machines.

The widespread use of hydraulic drive in machines has created the conditions for the development and creation of compact and powerful pulse devices, which are the basis for the executive bodies of mining, metallurgical, road, utility machines and other technological equipment. In the second half of the twentieth century, work on the creation of mobile, power-armed and high-performance impact machines was started and progressed rapidly.

Work on the creation of pulse technology was carried out at the Institutes of Mining and Hydrodynamics of the SB Academy of Sciences of the USSR, Karaganda State Technical University, SDB "Impulse" of the Academy of Sciences of the Kyrgyz SSR, Skochinsky Institute of Mining, Donetsk Scientific Research Coal Institute (DonUGI), MGI, VNIIstroydormash, Krasnoyarsk branch of VNIIstroydormash , the Siberian State Automobile and Highway University (SibADI) and other organizations that have identified priorities and directions in the development of domestic research in this field of technology.

The leaders of the development of the world market of pulse technology were the following firms: "Rammer-Tamrock", "Atlas Copco", "Scamec" (Finland – Sweden), "Krupp", "Hausalit" (Germany), "Montabert" (France), "Furukawa", NPK, "Huskie" (Japan), "Indeco", "Socomec", "Fxeco" (Italy), "Gullik Dobson", "JCB Hammermaster" (England), " Ingersoll Rand", "Caterpillar", "Shand", "Kent" (USA), "Silenced", MSB, "Dae- mo", "Hyundai", "Megaton", "Hanwoo", TNC, "Soosan" (South Korea), "Tabe" (Spain), Institute of Machine Science of the NAS of the Republic of Kyrgyzstan, etc.

The domestic and foreign experience of the last decade has confirmed the viability of this direction, but so far it cannot be said that it has a sufficient theoretical and practical basis, and the results of experimental testing and the accumulative fund of skills in using percussion machines have not been created.

The main purpose of the hydraulic system is to provide a given loading mode of the impact object. In turn, the system is an integral part of a machine that is technologically connected with other machines that carry out a certain technological process. Therefore, the study of the hydraulic system in order to establish its output indicators and internal parameters that meet the technical, operational, technological and other requirements for the system as a whole **is an urgent task**.

The aim of the work is to develop and scientifically substantiate the manufacturing technology of the main power element of the vibration mechanism of a low-frequency hydraulic power pulse system.

Objectives of the study:

- studying the classification, application areas and technologies of preparation of low-frequency hydraulic power pulse systems;
- studying the design of the hydraulic vibration module of power pulse systems, as well as technical and operational requirements for the most loaded elements of the system;
- development of a method for multi-stage rotary processing of the most loaded part of the hydraulic vibration module and the design of the cutting tool for its implementation;
- experimental study of the processing of the most loaded part of a hydraulic vibration module by the method of multi-blade rotary turning;
- improvement of the mechanical model of the hydraulic system and investigation of the stress-strain state of its loaded elements;
- calculation of the economic efficiency of the multi-blade rotary turning method and development of recommendations for production. Implementation of the results in production.

The object of the study: Manufacturing technology of the main power element "rod", which is the transfer link between the hydraulic drive and the object of impact.

Subject of the study: Regularities of the processing of the main power element "rod" by the method of multi-blade rotary turning.

Study methodology: Methods of theoretical and experimental research were used to perform the task of research of the dissertation work. Theoretical studies

are carried out on the basis of scientific provisions of such sciences as the theoretical foundations of the calculation of hydro-volume vibratory and impact mechanisms, theory of vibration engineering and technology, theory of automatic control system, theory of experiment planning, theory of cutting materials, design of cutting tools, mechanical engineering technology.

Experimental studies were conducted in the scientific laboratory of the Department "Technological Equipment, Engineering and Standardization" of Karaganda Technical University. The design of a special multi-blade rotary tool and the study of the stress state to optimize its geometric parameters, as well as the study of the stress-strain state of the hydraulic mechanism were carried out using the Explicit Dynamics calculation modules of the ANSYS program.

Scientific novelty of the work:

1. A mathematical model of the working process of a hydraulic vibration system has been created.

2. The main indicator has been established that affects the efficiency of energy transfer, this is the stiffness of the basic element.

3. A method of multi-blade rotary turning has been developed for processing the most loaded element "rod" of the hydraulic vibration module, as well as:

- optimal cutting modes have been established;
- the required roughness and hardness of the treated surface has also been achieved;
- mathematical models for estimating surface roughness and hardness have been developed.;
- an increase in productivity has also been achieved by reducing heat treatment and grinding operations from the technological process.

4. The stress-strain state of a hydraulic vibration mechanism was investigated for the first time using the computer program ANSYS Explicit Dynamics. The strength and rigidity of the elements of the hydraulic impact device and the soil are ensured. The margin of safety for a heavily loaded rod element was 1.57, which is within acceptable limits (1.5-2.0).

Scientific provisions submitted for protection:

- mathematical model of the working process of a hydraulic vibration system;
- the results of an experimental study of the method of multi-blade rotary turning;
- mathematical models for estimating the roughness and hardness of the treated surface;
- methodology and results of the study of the stress-strain state of the hydraulic vibration mechanism using the computer program ANSYS Explicit Dynamics.

Practical significance of scientific results:

- increase productivity by 3-4 times due to reduction of heat treatment and grinding operations from the technological process;

- developed recommendations for the production of rotary tools, the choice of optimal cutting modes and processing schemes;

- development of the design and production of a prototype of a multi-blade rotary tool.

The reliability of scientific provisions, conclusions and recommendations is confirmed:

- the correctness of the formulation of the research task, the validity of the research methodology for the application of scientific provisions of the science of hydraulic vibration mechanisms and mechanical engineering technology;

- satisfactory convergence of the results of the experimental study and the calculated data;

- conducting a production test of a multi-blade rotary turning method;

- patents of the Republic of Kazakhstan for invention and utility model;

- implementation of the results in production;

- publication of the main scientific results in the open press;

- wide approbation of the results of work at national and international conferences, at meetings of departments of leading foreign and domestic universities, as well as at technical meetings of mechanical engineering enterprises.

The dissertation work is aimed at fulfilling the main tasks

of the State Program of Industrial and Innovative Development for the period 2015-2019. The main results of the dissertation were introduced into the production of the Tumar Center for Innovative Projects LLP and into the educational process of the Karaganda Technical University in the preparation of bachelors and undergraduates in mechanical engineering.

Approbation of the work. The main provisions of the doctoral dissertation were reported and discussed at the meetings of the Department "Technological Equipment, Engineering and Standardization" of the KTU (2017-2021), at the meeting of the scientific seminar at the DC KTU (2017-2021), as well as at international conferences and technical meetings of machine-building enterprises:

- International Scientific and practical conference (Kiev, 2017);

- International Scientific and Technical Conference (Armavir, 2019.);

- International scientific and practical conference "Integration of science, education and production - the basis for the implementation of the National Plan" (Saginov Readings), (Karaganda, 2018-2020.);

The author's personal contribution consists in setting tasks and developing research methods, analyzing scientific and technical literature and conducting a patent search, developing a method for multi-blade rotary turning, designing and manufacturing a prototype of a special cutting tool, organizing and conducting experimental research, testing the results obtained at machine-building enterprises and universities.

Publications

Based on the materials of the dissertation, 13 works were published in Russian, Kazakh and English. Of these, 4 articles are in journals included in the databases of the rating agencies Thomson Reuters and Scopus, 3 articles are in publications recommended by the Committee for Ensuring Control in the Field of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan. The work was tested at 4 international conferences. Received 1 patent of the Republic of Kazakhstan for an invention and 1 patent of the Republic of Kazakhstan for a utility model.

Scope and structure of work.

The doctoral dissertation consists of an introduction, 5 chapters and a conclusion, set out on 130 pages of typewritten text, which are explained by 75 figures, 5 tables, a list of literature from 140 titles, 5 appendices.

CONCLUSION

1. During the dissertation work, as a result of the study of the design and manufacturing technology of low-frequency hydraulic power pulse systems, it was revealed that the most loaded element of the hydraulic vibration module is the "rod" part and there is a problem of ensuring the wear resistance and impact resistance of the loaded element, which lead to an increase in its service life.

2. To solve this problem, a method of multi-blade rotary turning has been developed for processing the most loaded element of the hydraulic vibration module of the "rod" part, as well as:

- a special multi-blade rotary tool has been developed and manufactured;
- optimal cutting modes have been determined: n_{shp}=870 rpm; S= 0,23 mm/r; t = 0,75 mm; β_{ust} = 15 degree;
- the roughness of the treated surface has been achieved R_a = 0,63 microns and the required surface hardness HB≤285;
- mathematical models are proposed to estimate the roughness and hardness of the surface;
- increased productivity and cost reduction have been achieved due to the exclusion of heat treatment and grinding operations from the technological process.

3. It is revealed that the output indicators of the working bodies of pulsed hydraulic machines do not correspond to the calculated indicators.

To solve this problem, a mathematical model of the working process of a hydraulic vibration system has been developed. It is also established that the rigidity of the main element is the main indicator affecting the efficiency of energy transfer.

4. The stress-strain state of the hydraulic impact device was studied using the computer program ANSYS Explicit Dynamics. The strength and rigidity of the elements of the hydraulic impact device and the soil are ensured. The margin of safety for a heavily loaded rod element was 1.57, which is within acceptable limits (1.5-2.0).

5. The calculation and comparison of the cost of the technological operation for processing the outer cylindrical surface of the "rod" part and the operation of multi-blade rotary turning was carried out, as a result, it was found that the cost of the operation of multi-blade rotary turning is 3.5 times less.

The results of the dissertation work were introduced into the production of the Tumar Center for Innovative Projects LLP (Nur-Sultan). The annual economic impact is 1.85 million tenge.