ABSTRACT

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

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on the topic «Improving the construction of submersible centrifugal pump»

Improving the design of the submersible centrifugal pump is an important trend in the development of pumping equipment technology. Currently, this pump type is extensively used in many different industries and infrastructure, and its design is always under the stage of improvement to ensure high efficiency, reliability and durability. This type of pump is widely used in various industries such as oil and gas, water supply, chemical manufacturing, and industrial plants. To ensure the efficiency, reliability and durability of these pumps, their design is constantly being improved.

One important area of improvement in the submersible centrifugal pump is to increase the efficiency factor. This can be achieved by improving the design, quality and performance of the impellers. The impeller is used to transfer power from the motor to the pumping part, so its quality and durability are extremely important. The impeller is the crucial component that determines the efficiency and performance of the pump. For this reason, a substantial part of the dissertation work was devoted to the development of a more efficient centrifugal pump impeller design.

In the conditions of modern economic relations there is a necessity to increase the efficiency of the use of products of machine-building production with the use, on a large scale, of the latest technologies. A major aspect in solving this problem is improving the quality of products manufactured by domestic producers, which will lead to the state's entry into the world market of mechanical engineering to the position of a leader. This is easy to achieve if the enterprise-manufacturer will conduct in-depth scientific research areas of its activities and introduce into the production process the latest technology. One of such native producers is a young but fast-growing enterprise in Kazakhstan - "KARLSKRONA LC AB" Machine-Building Plant LLP, working in the field of fluid flow management solutions in water supply, water treatment, heating, sewage, as well as various technological processes based on modern equipment and advanced Kazakh technologies. The plant is an authorized dealer and service partner of such leading world manufacturers of pumping equipment as Oddesse (Germany), Sulzer (Finland), Grundfos (Denmark). The plant manufactures pumping stations, submersible pumps, as well as control cabinets for them, using automatic equipment from ABB, Mitsubishi. So, research and development on improvement of submersible centrifugal pump design were carried out at the machine-building plant of KARLSKRONA LC AB LLP. Working on improvement of design of submersible centrifugal pumps on the basis of machine-building plant of "KARLSKRONA LC AB" LLP gives an opportunity to

develop domestic production in this industry. Research and development results of this work can be used to create new models of pumps with a higher level of efficiency and quality. This, in its turn, can increase the competitiveness of domestic production in the world market and attract new customers. In addition, work on the basis of the machine-building plant makes it possible to use existing resources and technologies to create innovative solutions and further develop production in this area.

The dissertation thesis is executed within the limits of the grant financing projects AP05134409 "Development of centrifugal pump design with the raised indicators of serviceability" and AP08857367 "Development of innovative technologies for improving energy efficiency and reliability of centrifugal pumps manufactured in Kazakhstan" and the results of the study were put into production at the machine-building plant "KARLSKRONA LC AB" LLP.

Relevance of the work.

In recent years, there has been a growing demand for more efficient and reliable submersible centrifugal pumps, especially in countries such as Kazakhstan, where industries such as mining and agriculture are important to the economy. By upgrading the impeller design, it is possible to increase pump performance and reduce energy consumption, which can have a significant impact on the productivity and profitability of these industries.

The improvement of submersible centrifugal pump design is relevant for several reasons:

1. Pump efficiency. Submersible centrifugal pumps are widely used in various industries, such as oil and gas, chemical, food, pharmaceutical, etc. Improvements in pump design can lead to improvements in pump efficiency, which improves production efficiency and economy.

2. Increased reliability. Improving pump reliability can reduce the likelihood of pump failure and increase pump life. This is especially important for industrial plants, where stopping a production line due to pump failure can result in significant financial losses.

3. Environmental Safety. In some industries, such as the chemical and oil and gas industries, there are high demands on environmental safety. Improvements in pump design can help reduce the risk of hazardous substances leaking into the environment.

4. Innovation and Development. The development of new technologies and materials, as well as innovative approaches to pump design, can lead to more efficient and economical pumps, which opens up new opportunities for the development and improvement of production.

Overall, improving the design of the submersible centrifugal pump is important for industry, economy and the environment. It can help improve production efficiency, reduce the risk of environmental problems, increase equipment reliability and foster innovation.

The purpose of the work is to improve the design of a centrifugal submersible pump in order to increase its efficiency, reliability and duration of the main components in the conditions of Kazakhstan.

Scientific novelty. A new methodology of computer aided design of modified impeller of centrifugal submersible pump which allows to design and create the geometry of flow channels and blade profile with higher precision has been developed.

Object of study. Submersible centrifugal pumps of UPP 13-7/6 and STR 15-4 brands.

Research objectives.

- improvement of centrifugal pump impeller design in order to increase pump efficiency;
- development of automated module for design of meridian section and profiling of centrifugal pump impeller blade;
- flow simulation and modeling;
- calculation of pump main units for strength, durability and vibration activity analysis using modern computer programs;
- creation of centrifugal pump wheel prototype with modified blades using 3D technologies.
- laboratory and industrial tests of the modified centrifugal pump.

Practical significance

The practical significance of improving the design of a submersible centrifugal pump lies in the potential benefits that can be achieved in various industries, including agriculture, mining and water treatment. By optimizing the impeller design, pump efficiency can be improved, resulting in higher performance and lower energy consumption. This, in turn, can lead to significant cost savings in the industries that use these pumps. The calculation methods, design methods and methods of manufacturing of test samples obtained as a result of the work, as well as the new impeller design can be applied in practice by domestic pump manufacturing plants and other enterprises of machine building industry.

Provisions made for the defense:

- automated module that allows to design and create the geometry of the impeller blade profile with greater accuracy in MATLAB and Python mathematical environment;
- results of modeling and simulation of flow movement in SCFLOW system;
- methodology for creating a prototype of modified centrifugal pump impeller
- results of calculations of the main pump units for strength, durability and vibration activity analysis;
- results of laboratory and industrial tests of the modified centrifugal pump.

Approbation of the research results.

The main provisions and scientific results were discussed at international scientific conferences and published conference materials:

1. The simulation of the service life of the rotary shaft of a centrifugal pump. 6th International BAPT Conference “Power Transmissions 2019”, Volume 287, 2019, pp.1-6. eISSN: 2261-236X

2. Prediction of durability of centrifugal pump shaft for pumping aggressive media. Modern technologies in mechanical engineering and foundry production:

Proceedings of IV International Scientific-Practical Conference. 2018, p. 223-230. ISBN 978-5-7677-2778-0

3. Additive Technologies in the Production of Centrifugal Pump Units. Proceedings of Satpayev Readings "Innovative Technologies - the Key to Successful Solution of Fundamental and Applied Problems in the Ore and Oil and Gas Sectors of the RK Economy", vol. I, 2019. p. 1410-1414, ISBN 978-601-323-145-7

4. Design and manufacture of a prototype of a centrifugal pump impeller by layering method. Proceedings of the Conference "Satpayev Readings -2020", 2nd volume, 2020, p.173-176. ISBN 978-601-323-209-6

5. Hydrophobization of the flow channels of the impeller of the centrifugal pump. Proceedings of the Conference "Satpayev Readings -2021», 2nd volume, 2021, p713-716. ISBN 978- 601-323-246-1

Publications. As a result of dissertation thesis Scopus and 4 articles were published in journals indexed in the Web of Science databases, 2 articles in the journal Vestnik KazNITU:

1. Computer simulation and investigation vibration parameters of a centrifugal submersible pump, (article). Journal of Vibroengineering, vol. 22, no. 5, pp. 993–1005, 2020, ISSN 17293774 https://doi.org/10.21595/jve.2020.21014, (Mechanical Engineering). Percentile: 39. Selection of materials for the review and its writing, methods and conclusions, dynamic calculation and analysis, preparation of graphs and their description.

2. Determination of the rational number of blades of the centrifugal wheel of a submersible pump (article). Eastern-European Journal of Enterprise Technologies. Applied Mechanics. vol. 2, no. 7,2020, pp. 49-58. ISSN 2226-3780 (print), ISSN 2312-8372 (on-line), https://doi.org/10.15587/1729-4061.2020.200998. (Mechanical Engineering). Percentile: 49. Search for publications for the review and its writing, writing sections: research methodology, research results, computer calculations of the centrifugal wheel for strength in the NASTRAN CAE system, design of graphs, responses to reviewers' comments.

3. Computational and Experimental Study of the Composite Material for the Centrifugal Pump Impellers (article). Journal of Applied and Computational Mechanics, 2022, vol. 8, no. 4, pp. 1407-1421, ISSN 2383-4536. https://doi.org/10.22055/JACM.2022.40366.3574, (2021) Mechanical Engineering, Percentile: 75. Search for publications for the review and its writing, methods and conclusions, numerical analysis of the strength of impellers, design of graphs, responses to reviewers' comments.

4. Mathematical Modeling of the Reliability of Polymer Composite Materials (article). Mathematics, vol. 10, no. 21, pp.1-19 ,2022, ISSN 22277390. https://doi.org/10.3390/math10213978, ISSN 22277390, (2021) (General Mathematics), Percentile: 86. Search for publications for the review and its writing, data processing, software.

5. Optimization of the main wheel of a centrifugal submersible pump using a prototype made by additive technology (article) Vestnik KazNRTU, № 1 (137), 2020, p. 418-426, ISSN 1680-9211. The methodology of end-to-end CAD/CAE/CAM design of the impeller, design work at the CAD stage, description

of the work of the automated module for designing the profile of the meridian section and the blade, the algorithm for drawing the blade profile in MATLAB.

6. Automation of designing a centrifugal pump impeller with a modified vane lattice. Vestnik KazNRTU, № 1 (143), 2021, p 135-143. eISSN 2709-4766. Search for publications for the review and its writing, calculation algorithm and flowchart for automating the calculation of the parameters of a wheel with a heterogeneous blade grid, design of graphs.

Patents. As a result of the dissertation work one utility model patent and one innovation patent were received:

1. Centrifugal pump impeller for industrial testing. The patent for useful model № 5979, 16.04.2021.

2. "Multistage centrifugal pump". Invention patent № 36034, 30.12.2022

Structure and scope of work. The dissertation work consists of an introduction, four chapters and a conclusion. The thesis contains: 106 pages, 60 figures, 18 tables, 80 bibliographic sources, 3 applications.