

ANNOTATION

to dissertation for Doctor of Philosophy (PhD) degree in 8D07110 - "Digital engineering of machines and equipment"

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RESEARCH AND DEVELOPMENT OF THE TECHNOLOGY OF FIBER CONCRETE PUMP BODIES MANUFACTURING

Assessment of current state of the scientific and technical problem being solved.

The main goal of machine construction at present is implementation of modern technologies that improve quality and reduce cost of product, contribute to creation of efficient and competitive technology, while not requiring large investments. The technology for manufacturing products from innovative materials is well-known and is mainly applied for building materials production. However, recent studies have shown an opportunity of using them as a material for industrial equipment cases.

Less rich and deep deposits tend to be developed, which leads to an increase in the cost of metals and products from them. Therefore, all over the world there is a search for replacing metals with composite materials with better technical and technological characteristics that have controlled properties and cheaper cost.

Justification of the need for this research work.

Increase of the efficiency of the Republic of Kazakhstan enterprises, which use pumping equipment in the process, requires implementation of production and repair of pumping equipment casings from innovative materials into practice. Lightweight, reliable and relatively inexpensive fiber-reinforced concrete hulls will replace cast-iron and aluminum hulls and will occupy their niche in the Kazakhstan market.

Scientific research on the topic of the dissertation was carried out within the framework of the grant "2018/BR05235618" on the topic: "Development and implementation of manufacturing technology for small-volume structures of drives for mining and metallurgical machines from fiber-reinforced concrete", for 2018-2020.

Information of planned scientific and technological level of the development, about patent research and conclusions from them. The scientific and technological level of the developments in the dissertation corresponds to the world trends, and the results are superior in many respects to the existing level of well-known developments.

On the topic of the research, a patent search was fulfilled within 10-15 years, which showed a lack of the similar studies. Based on the results of the dissertation topic research, a patent of the Republic of Kazakhstan for a utility model No. 6103 dated May 28, 2021 was obtained, see Appendix G.

Relevance of the topic.

In mechanical engineering, the main problem in the manufacture of pump casings is the risk of the production period. The body is the main part in which separate assembly units and parts are mounted, interconnected with required specification of the relative position. It captures the constancy of the secondary arrangement of the parts, both in the static state and during the operation of the pump, as well as the smoothness of operation.

Prefabricated body products are mainly made by investment casting. However, there are exceptions as more complex body products are made by welding. In order to choose the right way to obtain a workpiece, you need to study further mechanical processing process so that the total cost is minimal.

The main problem in the manufacture of centrifugal pump casings is a long production period. In this regard, different machines and fixtures are used, but in our study, the time spent was reduced by using a more modern CNC machine.

Availability of extensive experimental equipment for determining the working loads, high level of development of the applied theory of elasticity, good knowledge of physical and mechanical properties of materials make it possible to ensure long-term operation of equipment under normal operating conditions.

The main reason for the failure of centrifugal pumps is wear and damage to rubbing surfaces. Inspection of the damaged parts of the pumps showed significant wear of their friction surfaces. Considering that these parts operate in the presence of an aqueous medium, the main factor influencing frictional wear will be hydrogen wear. It arises as a result of the joint interaction of surface phenomena: exo-emission, adsorption and tribodestruction, which lead to the release of hydrogen. Along with non-equilibrium processes occurring during the deformation of the surface layer of the metal, thermal gradients, electric and magnetic fields and stress fields are created. This leads to the diffusion of hydrogen into the metal, its concentration in the subsurface layer, and accelerated wear or destruction of this layer. At mining and metallurgical complex enterprises, a large number of equipment operates in difficult operating conditions. This is an aggressive environment, high dustiness, sudden temperature changes, etc. Based on the above, equipment cases are made of expensive metals, have an increased thickness and, consequently, mass, and a short service life, which requires frequent replacement of equipment, significant material and labor costs.

At the same time, new composite materials that have appeared in other industrial sectors make it possible to replace metal and get rid of these shortcomings. The search for new composites with properties that make it possible to use these materials in mechanical engineering is very relevant.

The relevance of the topic is due to the fact that the use of fiber in concrete provides it with higher performance in terms of such characteristics as tensile strength, bending, shear, impact and fatigue strength, crack resistance, frost resistance, water resistance, heat resistance and fire resistance. In addition, the distinctive features of fiber-reinforced concrete are high anisotropy and discreteness. At the same time, such features contribute to the possibility of separating fiber-reinforced concrete into an independent group of structural materials that differ in structural features and properties.

This dissertation is devoted to solving these issues by searching for new composite materials with specific properties and technologies for their manufacture and application, which is very important.

Purpose of the study.

The purpose of this work is to increase the efficiency of machine-building enterprises by developing a new technology for manufacturing centrifugal pump casings using fiber-reinforced concrete and composite materials with improved characteristics and appropriate operating conditions.

The object of research is the technology for the production of pumping equipment and structural materials used in mechanical engineering.

The subject of research is fiber-reinforced concrete mixtures, which allow to increase the efficiency of machine-building production.

Research objectives.

During the research, it was necessary to solve the following tasks:

- Research of materials for new composite materials with improved strength characteristics.
- Theoretical substantiation of the rational ratio of the components of composite materials, providing products from them with improved strength and technological characteristics.
- Development of tooling for casting products from fiber-reinforced concrete and technology for manufacturing pump casings from it.
- Evaluation of effectiveness of the proposed technical and technological solutions.

Research methods.

When completing the dissertation, a comprehensive research method was used, including a critical analysis of scientific and technical literature and industrial production experience, theoretical research, laboratory experiments, design and technological developments, bench tests, statistical processing of experimental results using mathematical statistics methods.

Scientific provisions submitted for defense:

1. Fiber-reinforced concrete hulls are new effective chemically resistant products, durable lightweight products, in which the degree of filling with mineral fillers and aggregates reaches 90–95% of the mass, and fiber is used as a reinforcing component.
2. Fiber-reinforced concrete, which can be used as a structural material in mechanical engineering, must have a discontinuous aggregate granulometry, and its rational structure must be three-component, in which the size of each aggregate group must differ by an order of magnitude.
3. Fiber, which will be used in the production of pump casings, must have increased strength to loads, have low shrinkage, not form cracks, not lose properties under the influence of temperature and moisture.
4. To obtain fiber-reinforced concrete with specified strength characteristics, mixing of the components should occur at a rotational speed of the mixer working part of 600-800 rpm for 2 ... 3 minutes, and drying of the finished product should be carried out at a temperature of 80 °C.

Scientific novelty:

1. The regularity of the change in the strength of the product from the amount of additive to the fiber mixture has been established, which makes it possible to design and obtain pump casings with specified strength characteristics

2. A model has been developed for the rational structure of a fiber-reinforced concrete mixture with discontinuous aggregate granulometry, which makes it possible to obtain fiber-reinforced concrete of high density and strength, which allows it to be used as a structural material in mechanical engineering
3. The patterns of influence on the strength of hardened fiber-reinforced concrete of the mixing modes (speed of rotation of the working body of the mixer, mixing time of the components), temperature of the binder (epoxy resin) and drying temperature of the finished product have been established, which made it possible to substantiate the rational technological mode for manufacturing products from fiber-reinforced concrete.

The validity and reliability of scientific provisions, results and recommendations are based on the use of standard proven methods and research methods, the use of physical and chemical laws, the high convergence of the results of theoretical and experimental data, using methods of statistical processing of experimental results with a high correlation index.

The practical significance of the work.

The technical and technological feasibility, economic feasibility of using a new composite material - fiber-reinforced concrete is proved, the optimal composition is proposed as a material for manufacturing centrifugal pump casings. The developed methods for selecting rational compositions of fiber-reinforced concrete mixtures, the technology for their preparation and the technology for manufacturing centrifugal pump casings can be effectively used in mechanical engineering with enhanced performance during operation.

Personal contribution of the author.

It consists in formulating and substantiating the topic of the dissertation research, setting tasks and conducting theoretical and experimental research, formulating scientific provisions, proving their novelty, developing methodological support for the work carried out, developing conclusions and recommendations.

Approbation of the work.

The results of research on the dissertation were reported and approved at international scientific and practical conferences: II International Conference Essays of Mining Science and Practice. (2020); International Scientific and Practical Conference Proceedings of the Satpaev Readings "Satpaev Readings - 2020"; 2nd International Scientific and Technical Internet Conference "Innovative Development of Resource-Saving Technologies of Mineral Mining and Processing" Book of Abstracts. - Petroșani, Romania: UNIVERSITAS Publishing, (2019); Proceedings of the International Scientific and Practical Conference "Rational use of mineral and technogenic raw materials in the conditions of industry 4.0" (2019).

The research results were discussed at the scientific and technical councils: Haidaromunai LLP, Kyzylorda (2019, 2020); Eman-Expert LLP, Kyzylorda (2019); AZTM JSC (2020). At scientific seminars of the department "Technological machines and transport" "Satbayev University" (2019-2022).

Publications. During the doctoral studies, 11 co-authored works were published, including 2 articles in journals peer-reviewed on the Scopus database (Naukovyi Visnyk NHU, Web of Science) with a high Q2 quartile; 2 articles in journals recommended by the Education and Science Control Committee of the Ministry of Science and Higher Education; 1 article in a

journal recommended by the RSCI; 6 reports at International scientific and practical conferences, three of them in foreign countries (Romania).

Contribution of the dissertation student to the preparation of publications

1 "Study of the operation of centrifugal pump housings made of fiber-reinforced concrete under the influence of a water-sand mixture." Selection of materials for the review, writing a review and introduction, processing and description of the results of experiments, writing a conclusion.

2 "Analysis and study of the main types of fibers for use in fiber concrete mixes". Search for publications for a review and its writing, writing sections: research methodology, research results, design of graphs, responses to reviewers' comments.

3 "Justification of rational parameters for manufacturing pump housings made of fibroconcrete". Section writing: introduction, research methodology, mathematical processing and discussion of experimental results, article design.

4 "Polymer concrete and fiber concrete as efficient materials for manufacture of gear cases and pumps". Selection of materials for the review and its writing, writing an introduction, methods and conclusions, preparation of graphs and their description, article design.

5 "Development of technology for manufacturing molds for casting body parts". Writing sections: introduction, methodology, experiments and their results, article design.

6 "Polymer concrete - a new material for the manufacture of gear housings for mining machines." Drawing up an article plan, writing sections: discussion of research results and conclusions, article design.

7 "Fiber concrete is an effective material for the manufacture of pump housings". Development of a report plan, selection of materials, writing the main part with a discussion of the research results.

8 "Gearbox bodies made of polymer concrete for mining and metallurgical complex". Selection of material and its systematization, writing the main sections, design of the report.

9 "Methodology for conducting experimental studies of the parameters of a centrifugal pump with a casing made of fiber-reinforced concrete." Development of a report plan, selection and systematization of materials, writing two sections, presentation at a conference.

10 "Searching for new structural materials and manufacturing technology for durable casings of gearboxes and centrifugal pumps." Development of the article plan, writing a review, methodology and discussion of the results, responses to the comments of the reviewers.

11 "Modernization of metallurgical equipment with the development of an innovative method of coiling hot-rolled strips, Multi-authored monograph., Energy- and resource-saving technologies of developing the raw-material base of mining regions". Writing sections: relevance, methodology and conclusion.

The structure and scope of the dissertation.

The dissertation consists of an introduction, four sections, main conclusions, list of references and 10 appendices. The volume of the dissertation is 153 pages of typewritten text, 27 tables, 54 figures, a bibliography of 112 titles.