ABSTRACT

of the dissertation work on the topic:
«DEVELOPMENT OF COMPOSITE MATERIALS FOR REINFORCED FILLING AND MANUFACTURE OF GEARBOX HOUSINGS»
submitted for the degree of Doctor of Philosophy (PhD) in the specialty 6D070700 – «Mining»

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Justification of the need for this research work. Increasing the efficiency of mining and metallurgical enterprises by reducing the cost of materials dictates the need to search for new materials with improved characteristics and lower cost, which requires special studies that have been carried out in this work.

Scientific research on the topic of the dissertation was carried out within the framework of the grant «2018 / AP05131236» on the topic: «Modernization of mining and metallurgical equipment using innovative materials and drive arrangements», for 2018-2020.

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

On the topic of research, a patent search was carried out to a depth of 10-15 years, which showed the absence of similar research. Based on the results of research on the topic of the dissertation, the patent of the Republic of Kazakhstan No. 34808 dated 02.19.2021 was received.

The relevance of the research topic. The current stage of development of mineral deposits is characterized by a deterioration in the quality of mined ores, more complicated conditions for the development of minerals, and an increase in costs for the main mining processes. A significant number of ore deposits are developed by systems with backfilling of worked-out space with hardening mixtures. This allows you to significantly reduce the loss of minerals in the subsoil, but increases the cost of production. The hardening filling mixture is a composite material with adjustable strength characteristics. Therefore, studies aimed at increasing the strength of the backfill in ways that simultaneously reduce its cost is an urgent task in the development of mineral deposits by the underground method.

At the enterprises of the mining and metallurgical complex, a large number of equipment operates under severe operating conditions. This is an aggressive environment, high dust content, abrupt temperature changes, etc. Based on the above, the equipment housings are made of expensive metals, have increased thickness, and, consequently, weight, low 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 disadvantages. The search

for new composites with properties allowing the use of these materials in mechanical engineering is highly relevant.

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

The purpose of this work is to increase the efficiency of mining and metallurgical enterprises through the use of composite materials with improved characteristics corresponding to operating conditions.

Research methodology. In carrying out the thesis, 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 by methods of mathematical statistics.

Research objectives.

- Search for materials for new composite materials with increased 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 rational compositions of hardened filling mixtures and polymer concrete mixtures.
- Development of tooling for casting products from polymer concrete and technology for manufacturing gearbox housings from it.
- Evaluation of the effectiveness of the proposed technical and technological solutions.

Scientific provisions introduced for the defense:

1. The addition of basalt fiber to the hardening backfill mixture in the amount of 9 kg / m3 makes it possible to obtain a reinforced backfill capable of effectively resisting the seismic effect of blasting by increasing the impact strength.

2. Polymer concrete, which can be used as a structural material in mechanical engineering, should have an intermittent granulometry of the aggregate, and its rational structure should be three-component, in which the size of each group of aggregate should differ by an order of magnitude.

3. To obtain polymer concrete with specified strength characteristics, mixing of the components should take place at a rotational speed of the mixer working body of 800-1000 rpm for 3 ... 4 minutes, and the finished product should be dried at a temperature of 130 ℃.

Scientific novelty of research

1. The regularity of the change in the impact strength of the reinforced fill from the amount of addition to the mixture of basalt fiber has been established, which makes it possible to design and obtain a fill mass with specified strength characteristics

2. A model has been developed for the rational structure of a polymer concrete mixture with an intermittent granulometry of the aggregate, which makes it possible to obtain polymer concrete of high density and strength, which makes it possible to use it as a structural material in mechanical engineering.

3. The regularities of the influence on the strength of the hardened polymer concrete of the mixing modes (the frequency of rotation of the working body of the mixer, the mixing time of the components), the temperature of the binder (epoxy resin) and the drying temperature of the finished product were established, which made it possible to substantiate a rational technological mode of manufacturing products from polymer concrete.

The validity and reliability of scientific statements, results and recommendations is based on the use of standard proven techniques and research methods, the use of physical and chemical laws, high convergence 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 developed and recommended composition of the reinforced hardening fill allows to increase the impact strength of the filling mass while simultaneously reducing the consumption of an expensive binder. This makes it possible to expand the area of use of systems for the development of mineral deposits with solidifying backfill of mined-out space.

The technical feasibility and economic feasibility of using a new composite material - polymer concrete of the proposed composition as a material for the manufacture of gearbox housings - have been proved. The developed methods for the selection of rational compositions of polymer concrete mixtures, technologies for their preparation and technologies for manufacturing gearbox housings can be effectively used in mechanical engineering with increased performance during operation.

The personal contribution of the author consists in the formulation and substantiation of the topic of the dissertation research, the setting of tasks and the conduct of theoretical and experimental research, the formulation of scientific provisions, in the proof of their novelty, the development of methodological support for the work carried out, the development of conclusions and recommendations.

Approbation of 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 "Satpayev 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); International scientific and practical conference "Rational use of mineral and technogenic raw materials in the conditions of industry 4.0" (2019).

On scientific and technical councils: LLP "Khaidaromunai", Kyzylorda (2018); Branch of the corporation "General Electric International Inc." in the Republic of Kazakhstan. Divisions of GE Transportation (2019); Zerde-Keramika LLP, Shymkent (2019); Eman-Expert LLP, Kyzylorda (2019); AZTM JSC (2020).

At scientific seminars of the departments "Mining" and "Technological machines, transport and logistics" "Satbayev University" (2019-2021).

Publications. 16 scientific papers have been published on the topic of the dissertation, including publications include 5 articles in journals included in the Scopus database (Naukovyi Visnyk NHU, Mining of Mineral Deposits, Eastern-European

Journal of Enterprise Technologies, Web of Science, IOP Conference Series: Materials Science and Engineering) with a high quartile Q2; 2 articles in journals recommended by the Committee for Quality Assurance in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan; 1 article in the journal recommended by the RSCI; 5 reports at International scientific and practical conferences, three of them in the far abroad (Romania); 3 articles in leading scientific journals from different countries.

Contribution of the candidate to the preparation of publications

1 «Studying fiber - reinforced concrete for casting housing parts of pumps». Selection of materials for the review, writing a review and introduction, processing and describing the results of experiments, writing a conclusion.

2 «**Substantiation and process design to manufacture polymer-concrete transfer cases for mining machines».** Search for publications for a review and its writing, writing sections: research methods, research results, graphing, responses to comments from reviewers.

3 «Justification of rational parameters for manufacturing pump housings made of fibroconcrete». Writing sections: 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 «On the reliability of technological innovation systems». Writing sections: introduction, methodology, experiments and their results, article design.

6 «Investigation of the optimal composition of fiber-reinforced concrete for the manufacture of centrifugal pump casings». Drawing up an article plan, selecting materials for a review, writing an introduction, review and conclusion.

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

8 «Increasing the strength of the hardening backfill by reinforcing basalt fibers». Drafting of the report plan and its complete preparation.

9 «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 research results.

10 «Gearbox bodies made of polymer concrete for mining and metallurgical complex». Selection of material and its systematization, writing of the main sections, presentation of the report.

11 «Methodology for experimental studies of the parameters of a centrifugal pump with a housing made of fiber-reinforced concrete». Development of a report plan, selection and systematization of materials, writing two sections, speaking at the conference.

12 «Use of air bellows for low - speed drive mechanisms». Search and selection of materials for the review and its writing, statistical processing of research results and their description, writing a conclusion.

13 «Reliability Estimate of Technical systems containing composite materials through analysis of the concurrent risks». Development of the plan and structure of the report, systematization of the material and writing of the main sections, presentation of the report.

14 «Manufacturing prospects for polymer concrete gear box». Systematization of experimental data and description of research results, writing of sections: methodology and discussion of results, design of the article.

15 «The search for new construction materials and technology for the manufacture of durable gearboxes and centrifugal pumps». Development of an article plan, writing a review, methodology and discussion of the results, replies to the comments of reviewers.

16 «For the reliability and safety of the person from the technical and economic systems». Writing sections: relevance, methodology and conclusion.Объем и структура диссертации

The dissertation consists of an introduction, 4 chapters, main conclusions, a list of used literature sources and 10 appendixes.

The volume of the thesis is 107 pages of typewritten text, 30 tables, 48 figures, 95 literary sources.

The main content of the work

Industrial revolution 4.0 for its active and effective implementation requires the use of new materials with improved technological properties, cheaper and more durable. This will allow replacing traditionally used metals - cast iron, steel, various alloys.

Among the new composite materials that can be used in mining, one can single out a reinforced insert to improve the strength and rheological characteristics, as well as polymer concrete for the manufacture of machines and mechanisms.

It is very important to get a bookmark with high strength characteristics, but at the same time with a lower cost. The solution to this problem can be facilitated by the use of a reinforced bookmark.

The analysis of literary sources and work practices of mining enterprises in Kazakhstan, CIS countries and far abroad showed that the use of reinforced filling is not given due attention, although the quality of artificial massifs from the hardening filling and its cost require fundamental improvements.

Another promising direction in the use of composite materials should be considered the use of polymer concrete in mechanical engineering.

The analysis of the state of the art - the expansion of the use of composite materials in mining has shown that at present there are few studies that would substantiate the possibility, efficiency and economy of using such new materials. For these purposes, as the analysis has shown, it is necessary to solve a number of scientific, technical and design problems.

1.In the direction of using the reinforced insert:

- Justify the use of a certain type of reinforcing element;
- to establish a rational amount of a reinforcing element;

- to propose rational compositions of the bookmark with a reinforcing element;

- to develop a technology for preparing a reinforced bookmark.

2. In the direction of using polymer concrete for the manufacture of gearbox housings:

- Investigation of the gearbox housing operation;

- search for rational components for polymer concrete;

- the search for a rational composition of the polymer-concrete mixture for the manufacture of the gearbox housing and its experimental confirmation;

- design and technological development of equipment for casting, gearbox housing made of polymer concrete;

- experimental studies of the technology of casting the gearbox housing from polymer concrete;

- semi-industrial tests of the gearbox housing made of polymer concrete;

-evaluation of the economic efficiency of the use of gearboxes made of polymer concrete.

As in traditionally reinforced structures, the reinforcement of the fill with fibers or fibers is based on the fact that the applied load is transferred to the fibers by means of tangential forces acting at the interface, and if the elastic modulus of the reinforcing elements is greater than the elastic modulus of the mixture, then the main part of the applied stresses is absorbed by the fibers. and the overall strength of the filling mass is proportional to their volumetric content. The efficiency of the filling with basalt fibers that strengthen them depends on the nature of their location and orientation in the massif.

For experimental confirmation of the proposed method of strengthening the backfill, it was necessary to solve two problems.

The first is the establishment of the fact of an effective increase in the strength of the reinforced insert in comparison with the traditional one and the identification of the laws governing the dynamics of this process.

The second task is to determine the optimal addition of basalt fiber to strengthen the hardening backfill.

The composition used at the Mallevsky mine of the Zyryanovsky mining and processing complex of Kazzinc LLP was used as the basic composition of the filling mixture.

Studies have established that the volume fraction of the fiber in the array should be large enough so that the fraction of the load taken up by the fibers is as large as possible. However, if the content of fibers in the material exceeds a certain level, then this will lead to a deterioration in the properties of the material due to the fact that the mixture is not able to impregnate all the fiber bundles. As a result, the adhesion of the fibers to the mixture decreases, and voids may form in the massif.

In order to establish the optimal addition of basalt fiber for hardening the hardening fill, experiments were carried out.

Statistical processing of the experimental results made it possible to obtain a mathematical expression for the dependence of the strength of the insert on the amount of addition to the mixture of a reinforcing element - basalt fiber, which has the form:

$$\sigma=0{,}0489m^2+0{,}9869\ \text{МПа},\quad \sigma<m<12 \qquad (1)$$

here σ – bookmark strength, MPa,
m – mass of basalt fiber in the volume of the mixture, kg / м^3;

Graphically, this dependence is shown in Figure 1

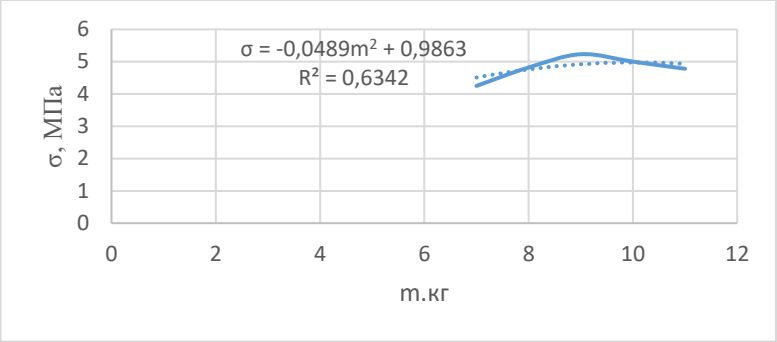


Figure 1 - Dependences of the strength of the insert on the amount of addition to the mixture of a reinforcing element - basalt fiber

Analysis of the experimental results shows that the optimal amount of the reinforcing element is the addition of basalt fiber 9 kg / m^3. At the same time, the mixture has the best strength characteristics, while maintaining the necessary mobility.

As studies have shown, to achieve the design strength of the filling of 4.0 MPa (this is practically the maximum required strength for most mining enterprises in Kazakhstan), when using filling mixtures reinforced with basalt fibers, it is possible to reduce the cement consumption by 35 ... 42 kg / m^3. At the same time, the reinforced insert with the same strength of 4.0 MPa will be much more effective with resisting the shock seismic impact of blasting operations.

In the manufacture of composite materials, it is important to select the initial components. The final characteristics of the new material will depend on their composition, physicochemical and technical characteristics: strength, Poisson's and Young's moduli, manufacturability, and processing ability. Moreover, these characteristics should largely correspond to the requirements for products to be made from a new composite material. In our case, this is a gearbox housing that experiences certain loads from static and dynamic forces, vibration and a number of others that arise during the operation of the gearbox.

The analysis of the materials used for the preparation of polymer concretes, taking into account the acquisition of properties for the manufacture of gearbox housings, made it possible to accept the following initial components for further research:

- coarse aggregate - rubble rubble;
- fine aggregate - quartz sand;
- filler - quartz flour;
- binder - ED-20 epoxy resin.

In order to achieve improved strength and elastic characteristics of hardened polymer concrete, it is first of all necessary to ensure that the mixture is homogeneous.

The foregoing allows us to conclude that the main factor providing guaranteed characteristics of polymer concrete is the optimal structure of the mixture, i.e. a rational ratio of the components that make up the mixture, and then the method and technology for preparing the mixture itself - high-quality mixing of the components.

For this, special studies were carried out to substantiate the rational structure of the mixture and, as a consequence, the quantitative ratio of its components - fillers and binder.

This problem was solved by combining theoretical studies with experimental verification of their results.

Having carried out some theoretical studies, in particular, volumetric modeling, it was found that for the most dense filling of air voids in the mixture, it must have an intermittent granulometry, they consist of 2-3 fractions. The grain sizes of each of the fractions should differ by about an order of magnitude from each other. This is due to the voidness of the aggregate.

Figure 2 shows how the granules are located, for example, with a size of 1.2 mm; 0.2 mm and 0.02 mm, in a mixture. If you display all the granules in volume, in the figure, then the large ones will obscure the small ones. For clarity, only a few granules are left, and the larger ones are transparent.

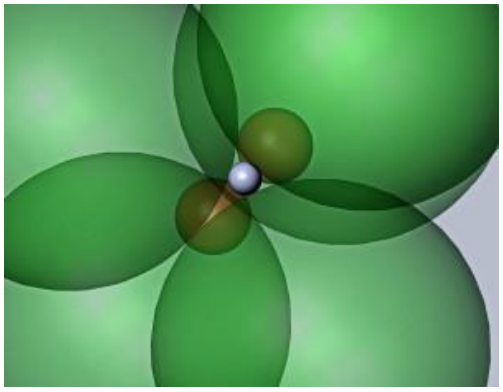


Figure 2 - Arrangement of granules with sizes of 1.2 mm; 0.2 mm and 0.02 mm, mixed

In this case, the voids in the coarse grains (rubble rubble) are filled with smaller particles (quartz sand), and the voids in the fine aggregate are filled with a fine filler (quartz flour).

As a result, a dense structure appears, which ultimately provides high strength of polymer concrete during its hardening. This provision formed the basis of the method for choosing a rational composition of polymer concrete for the manufacture of the gearbox housing.

The correct ratio of the different aggregate fractions is very important when designing the mix. An excessive content of filler, as well as an excessive content of fine fractions, will entail the production of an excessively viscous mixture, which will

further complicate the casting of products from it, as well as a large accumulation of air at the surface layer.

A large amount of coarse fraction can cause insufficient resin impregnation of it, which can lead to defects in the product due to uneven shrinkage of the mixture during the manufacture of the product from it.

For our case, the amount of coarse fraction should be 59%, medium-28%, fine-13%. The small amount of fines needed to fill the spaces between the larger ones has a beneficial effect on the amount of resin required for the mixture, because the fine fraction thickens the composite mixture most of all due to the large wetted surface area.

According to this technique, a rational composition of the polymer concrete mixture was selected for further research:

- rubble rubble - 50-52%, quartz sand 25-27%, quartz flour 10.5-11.5%, ED2 resin - 20%. The composition is protected by the RK patent No. 34808.

One of the main characteristics of polymer concrete, which is supposed to be used for the manufacture of gearbox housings, is its compressive and flexural strength. In order to determine these characteristics for the selected composition of polymer concrete, special studies were carried out using the following method.

Analysis of these experiments led to the following conclusions.

1. The bending strength of the sample in polymer concrete is almost 5 ... 6 times higher than the strength data given in the literature and is 80-85 MPa.

2. The highest strength was shown by the probes made with rubble rubble filler.

Analysis of the experimental data made it possible to state the following.

The highest strength is characterized by the composition of polymer concrete based on rubble rubble, quartz sand and flour. It is 10 ... 12 times higher than the data of literary sources for building polymer concrete and is 130-135 MPa.

Thus, for further research, one should focus on this composition of polymer concrete. According to its characteristics, it fully meets the structural materials for the manufacture of gearbox housings by casting. This is the required compressive and flexural strength, as well as the high mobility of the mixture after its preparation. The obtained characteristics of the proposed composition of polymer concrete make it possible to manufacture gearbox housings with reduced wall thickness and lower mass, which makes it possible to obtain a product with a low cost. To do this, it is necessary to develop the appropriate technology and develop the appropriate equipment for it.

As the analysis has shown, the best technology for manufacturing gearboxes is their casting.

This technology is the most advanced, low-cost, eliminating the need for mechanical processing of parts, ensuring high precision in their manufacture.

Foundry silicone was used as a material for the formation of external and internal surfaces.

The design of the matrix is proposed, which allows, with a high degree of manufacturability, to produce casting of polymer concrete products using existing mechanization devices with minimal manual labor (Fig. 3).

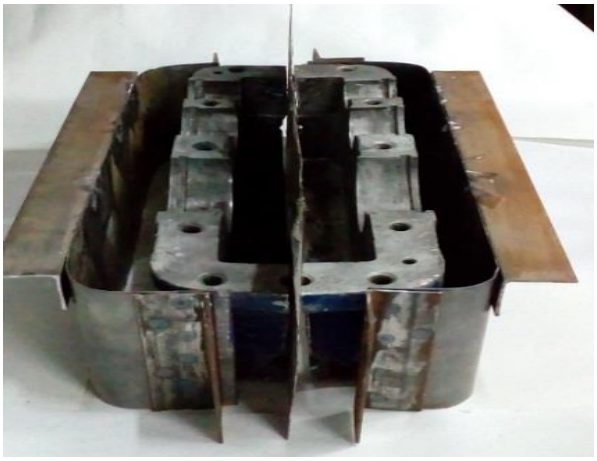


Figure 3 - Installing the dividing plate into the gearbox base frame

As stated earlier, it is important to obtain a homogeneous polymer concrete mixture.

The frequency of rotation of the working body of the mixer provides an effective distribution of the components of the polymer concrete mixture with their uniform distribution throughout the entire volume. This makes it possible to obtain polymer concrete with guaranteed characteristics. In order to obtain the regularities of the influence of the high-speed mode of operation of the mixer, laboratory experiments were carried out.

After statistical processing of the experimental results, the regularity of the influence of the rotational speed of the working body of the mixer on the strength of polymer concrete was obtained, shown in Figure 4.

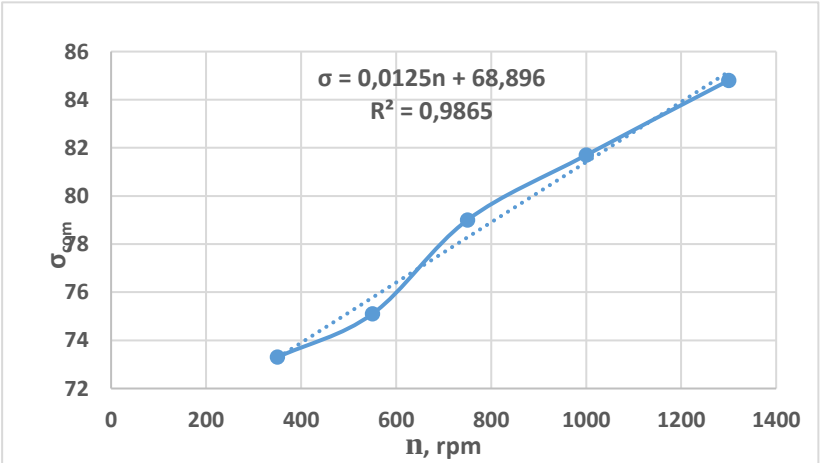


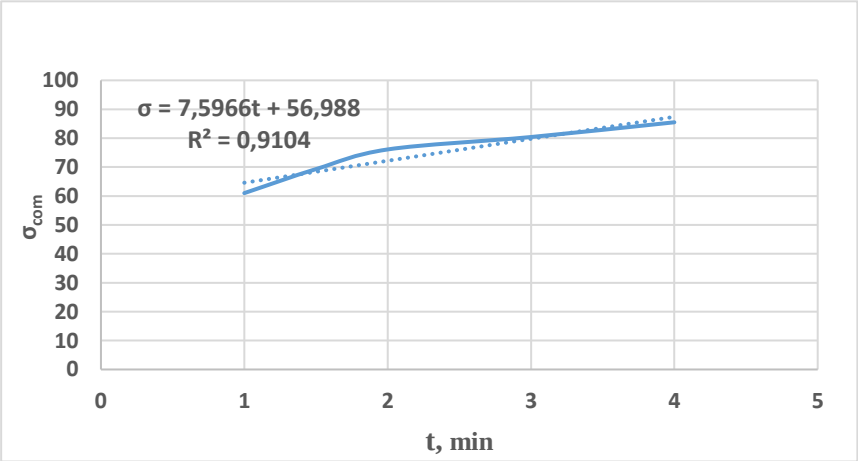
Figure 4 - The regularity of the influence of the rotational speed of the working body of the mixer on the strength of polymer concrete

The analysis of the obtained regularity allows us to conclude that the strength of polymer concrete grows in proportion to the increase in rotation frequency. This is due to the homogenization of the mixture, which ensures the isotropy of the hardened polymer concrete. However, to obtain the required strength of polymer concrete 75 ... 80 MPa, a rotation frequency of 600 ... 900 min^{-1} is sufficient. A further increase in the rotation speed will lead to excessive consumption of electricity and an increase in the cost of polymer concrete.

One of the most important factors affecting the quality of the polymer concrete mixture is the mixing time. Taking into account the difference in the characteristics of the starting materials, it should be sufficient for the uniform distribution of all components in the volume of the mixture. This will ensure its homogeneity, which in turn makes it possible to rationally place it in the forms without the formation of internal voids (cavities), which remove the strength of the hardened polymer concrete.

According to the results of statistical processing of these data, Figure 5 shows a pattern that describes this process.

Analysis of the experimental results showed that to achieve the required strength of polymer concrete for the manufacture of gearbox housings, a mixing time of 3 ... 4 minutes is quite sufficient. Further mixing time does not lead to a significant increase in strength, so it is irrational to increase it.

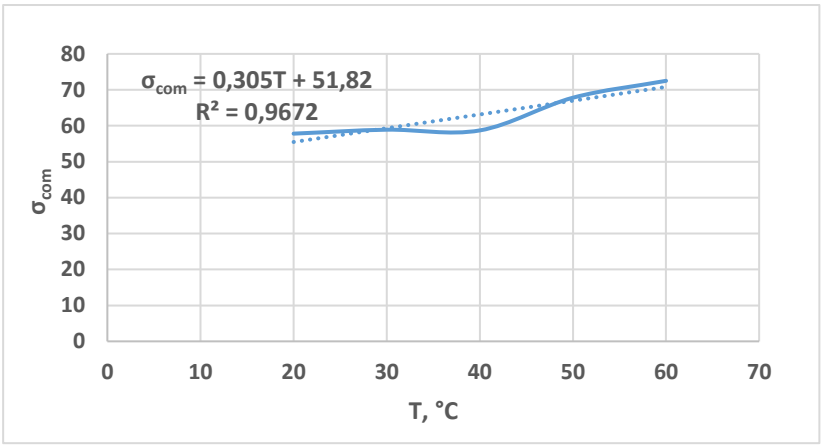


Picture 5 - Dependence of the influence of the mixing time on the strength of the hardened polymer concrete

An important role in the binding of polymer concrete components is the temperature of the resin. In the final version of the polymer concrete composition proposed for the casting of gearbox housings, the rational content of EDN resin in the amount of 11% was previously established.

For a better mode of operation of the resin, as a binder for a well-enveloping aggregate grain, a study was carried out of the effect of the temperature of the resin on the final result - the strength of the hardened polymer concrete.

As a result of statistical processing of the experimental results, the regularity of the effect of heating EDN-20 on the strength of polymer concrete products was obtained, shown in Figure 6.



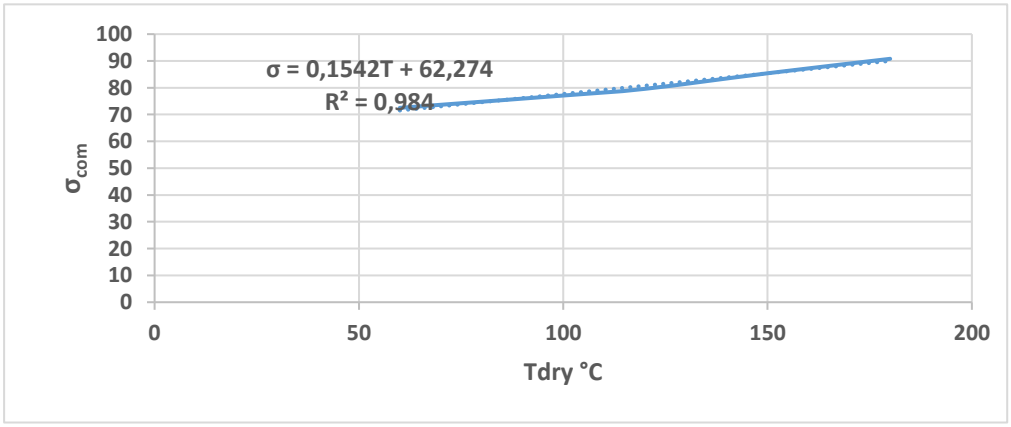
Picture 6 - Effect of resin temperature on the strength of hardened polymer concrete

As the results of experiments have shown, in order to achieve the required strength of polymer concrete products, it is necessary to heat the epoxy resin to a temperature of 60°C. This temperature makes it possible to increase the fluidity of the resin and provide conditions for better enveloping of the aggregate grains of the mixture.

Strength gain during hardening of polymer concrete products can take a fairly long period. Therefore, this process must be intensified by subjecting the finished product to drying.

For this purpose, experiments were carried out with the recommended composition of polymer concrete.

Figure 7 shows graphically this pattern and the regression equation after statistical processing of the experimental results.



Picture 7 - Influence of drying temperature on the strength of polymer concrete products

The analysis of the obtained results showed that to achieve the specified strength, the drying temperature is 120...130^{0}C. It provides a consistently specified strength of polymer concrete products.

Thus, these studies made it possible to identify a number of regularities, the use of which makes it possible to design polymer concrete mixtures with guaranteed characteristics.

On the basis of the obtained patterns and research results, the "Technological instruction on the technology of polymer concrete mixture preparation" was developed.

A very important point for obtaining castings of gearbox housing parts that meet the requirements of TC is their molding from polymer concrete. Taking into account the fact that the casting of parts from polymer concrete differs significantly from the technology of casting from metals, special studies were carried out, which made it possible to work out the casting technology taking into account the peculiarities of polymer concrete mixtures.

Research has worked out the best options for these operations.

The research carried out made it possible to develop a «Technological instruction for the casting of elements of gearbox cases C2-250 from polymer concrete». This instruction allows you to regulate all actions for casting the elements of gearbox housings from polymer concrete mixture and ensures high quality products.

Based on the results of the work carried out, the lower and upper covers of the C2-250 gearbox were cast (Figure 8 - 9), the gearbox was assembled and submitted for testing.

Figure 8 - Top cover gearbox housing

Figure 9 - Bottom cover gearbox housing

For comparative tests of the Ts2-250 gearbox with a polymer concrete casing and a metal casing, a special stand was developed and manufactured.

In the course of bench tests, the condition of the gearbox housing made of polymer concrete was assessed. It was carried out according to two criteria: in appearance: roughness, waviness, the presence of pores and shells, sagging, etc.

Thus, tests have established that a gearbox with a polymer concrete housing is not inferior in its characteristics to metal housings, and surpasses them in a number of parameters.

Conclusion

The dissertation is a scientific and qualifying work, which provides a new solution to the problems of increasing the impact strength of artificial filling massifs by reinforcing the hardening fill with basalt fiber and justifying the use of polymer concrete for the manufacture of gearbox housings. The studies carried out made it possible to formulate the following conclusions and recommendations.

1.The technological revolution 4.0 requires widespread use of new materials with improved characteristics to significantly improve production efficiency, reduce production costs and increase labor productivity.

2. Artificial filling massifs must resist destruction from the impact of rock pressure and seismic action of blasting operations. Clogging of the ore mass with backfill material leads to a decrease in the extraction of useful components during enrichment, which requires an increase in the impact strength of the backfill.

3.It has been established that the reinforcement of the hardening backfill with basalt fiber fibers in the amount of 5 ... 7% of the binder mass allows to increase the impact strength of the artificial backfill mass to obtain the standard strength of the backfill while reducing the consumption of the binder by 18 ... 20%.

4.The most rational is the structure of the polymer concrete mixture, which has a three-component composition of the filler with intermittent granulometry, where the fine aggregate fills the voids in the coarse, and the thin - in the fine, and the granulometric composition of the coarse, fine and fine aggregate should differ from each other by an order of magnitude.

5. Theoretical and experimental studies for the manufacture of gearbox housings recommended the composition of the polymer concrete mixture (% by weight): rubble rubble 50-52%, quartz sand 25-27%, quartz flour 10.5-11.5%, epoxy resin 20%, hardener 2%. This composition is protected by a patent of the Republic of Kazakhstan.

6. The main factors affecting the strength of polymer concrete and products made from it are the rotational speed of the working body of the mixer, the mixing time of the components, the temperature of the resin, the parameters of vibration compaction, as well as the drying temperature of the finished product. Rational parameters for the preparation of polymer concrete mixture and its curing in the product have been experimentally established:

- frequency of rotation of the working body of the mixer 600 - 800 rpm
- time of moving components 3 ... 4 min
- resin temperature 60 C°
- vibration frequency of vibration at molding a mixture of 2900 ± 100 rpm
- vibration amplitude of vibration roll 0,4±0,05 мм.
- duration of vibration 100±30 с
- drying temperature of the finished product 120...130 ^{0}C

7. The developed technological instructions for the preparation of polymer concrete mixtures and the casting of gearbox housings from them allow ensuring a stable production process with a guarantee of high quality products.

8. Conducted comparative bench tests of Ts2-250 gearboxes with metal and polymer concrete housings showed that a reducer with a polymer concrete casing is not inferior in its characteristics to metal housings, and surpasses them in a number of parameters: the weight is reduced by 2 ... 2.5 times, wall thickness - by 18-20%, the predicted service life increases by 1.5 times, the cost is lower by 37.4%.

9. The economic calculations carried out showed that the economic effect is:

- ✓ from the introduction of hardened filling with basalt fibers per 1 million tons of ore extraction 243.6 million tenge;
- ✓ 89668.7 tenge per one gearbox housing C2-250, which, calculated for the annual production of 1000 gearboxes, will amount to 86.688 million tenge.