Name of the topic of the project: Improving the quality of restoration of agricultural machinery parts by developing repair composite mixtures based on polymers, minerals and nano-additives.

Actuality: The state program for the development of the agro-industrial complex of the Republic of Kazakhstan for 2017-2021 provided for an increase in the provision of agricultural machinery at times, as well as technical modernization of the agro-industrial complex with the use of innovative resource-saving technologies. In the conditions of economic crisis, rural producers cannot ensure constant purchases of equipment at the level of demand. Problems of high level of wear and tear of agricultural machinery, lack of development of the service system, low efficiency of work on restoration of agricultural machinery parts are the most important during seasonal work. Improving the efficiency of repair and restoration of agricultural machinery parts is possible by well-known methods using effective composite materials: polymers, ceramics and nanodispersions.

Repair composite materials based on polymers, minerals containing nanoparticles are currently in high demand. Scientific research and practical work in this area are very relevant. The use of the proposed compositions of repair mixtures based on the study of physical and chemical properties will reduce the labor intensity and cost of work in the restoration of various parts of machinery and equipment. In accordance with the innovation policy of Kazakhstan, the state program for the development of the agro-industrial complex of the Republic of Kazakhstan for 2017-2021, the use of new materials will improve the repair and restoration of worn-out parts of equipment.

Goal of the project: Development of new compositions of repair composite mixtures based on polymers, minerals with nano-additives with improved characteristics for the restoration of machine parts.

Expected results:

As a result of the use of new materials and technologies, it is possible to increase the service life of parts of agricultural machines, reduce the period of repair work. The results of the project have prospects for opening new enterprises using the demanded high-tech technologies. The proposed composite materials should ensure the efficiency of repair and restoration of agricultural machinery parts, reduce the costs of small and medium-sized business producers, in the context of the economic crisis, for the purchase of new equipment. The use of new materials will improve the repair and restoration services for worn-out equipment parts. In the environmental aspect, the application of the results obtained will reduce the anthropogenic impact of industrial waste on the environment through their disposal.

Based on the research results, at least 2 (two) articles and (or) reviews will be published in peer-reviewed scientific journals in the scientific direction of the project, indexed in the Science Citation Index Expanded of the Web of Science database and (or) having a CiteScore percentile in the Scopus database of at least 35 (thirty five), 2 (two) articles or reviews in a peer-reviewed foreign or domestic publication, recommended by the Committee for Control in the Field of Education and Science, 2 articles at international conferences of foreign countries with the

publication of abstracts, and a patent will be obtained in the Kazakhstan patent office.

Upon completion of the project, there will be:

- developed new composite materials based on silicates and industrial waste for the restoration of agricultural machinery parts;

- the scientific and technical foundations for obtaining new composite materials based on silicates and industrial waste for the restoration of agricultural machinery parts have been developed.

Members of the research group:

Kokayeva G.A. – project manager, candidate of technical sciences, specialty 05.16.02 – Metallurgy of ferrous, non-ferrous and rare metals, associate professor of the Department "Technological machines and equipment" of S. Seifullin KATRU. Research area: composite and powder materials, coatings, materials science, powder metallurgy, non-ferrous metals metallurgy. Hirsch Index – 4. Link to the profile of the scientometric database Scopus: https://www.scopus.com/authid/detail.uri?authorId=57203342166

Nurlankyzy Zh. – chief researcher, master of technical sciences, senior lecturer of the department "Standardization, metrology and certification" of S.Seifullin KATRU, specialist in the field of quality management of products and processes of the construction industry, accreditation of certification laboratories, testing of building materials. Research area: minimization of risks in construction, consequences of risks in construction, quality control and safety of building materials. Hirsch Index – 1. Link to the profile of the scientometric database Scopus: https://www.scopus.com/authid/detail.uri?authorId=57195913629

Serekpayeva M.A. – senior researcher, master of technical sciences in the field of standardization, doctoral student of the Department "Standardization, metrology and certification" of S. Seifullin KATRU. Research area: recycling and use of industrial wastes, protective coatings, standardization of new materials. Link to the profile of the scientometric database Scopus: https://www.scopus.com/authid/detail.uri?authorId=57779484600

Ibzhanova A.A. – senior researcher, master of technical sciences in the field of standardization, senior lecturer of the Department "Standardization, metrology and certification" of S. Seifullin KATRU. Research area: product quality and safety, standardization, recycling and use of industrial wastes. Link to the profile of the scientometric database Scopus: https://www.scopus.com/authid/detail.uri?authorId=57780174100

Kardybay S. – senior researcher, master of technical sciences, assistant of the Department "Technological machines and equipment" of S. Seifullin KATRU, specialist in the field of structural materials and agricultural machinery. Research area: agricultural machinery and technological equipment.

Aldabergenova S.S. – researcher, PhD, senior lecturer of the Department "Standardization, metrology and certification" of S. Seifullin KATRU. Research area: product quality and safety, standardization of new materials. Hirsch Index – 1. Link to the profile of the scientometric database Scopus: https://www.scopus.com/authid/detail.uri?authorId=57190729374

Abuova A.B. – junior researcher, a master's student at the S.Seifullin KATRU. Research area: product quality and safety, standardization of new materials.

The results obtained:

During the implementation of the project "Improving the quality of restoration of agricultural machinery parts by developing repair composite mixtures based on polymers, minerals and nano-additives" for the period 2021-2023 the following results were obtained:

During the implementation of the project in 2021:

An analytical review was carried out, the organizational and technical principles of the system for the restoration of parts were determined, an analysis of the applied and innovative ways of restoring parts of agricultural machinery was carried out. The risk assessment of agricultural machinery parts from farms in various regions of Kazakhstan was carried out. The most problematic details are evaluated. Risks from various types of corrosion have been identified. As a result, the main defects were identified-the risks that may arise during the restoration of agricultural machinery parts, as well as the risks that determine the causes of defects were identified. The properties of materials are investigated and the dependence of the properties of materials is revealed. Theoretical and practical prerequisites for the development of compositions of repair composite materials are determined, a theoretical review is carried out. The properties of structural epoxy resins most in demand on the market have been studied: the amount of chlorine, the degree of abrasion by abrasives, resistance to temperature influences, chemical resistance, data on the study of epoxy resins have been obtained. The most demanded epoxy resins for further development of polymer composite materials have been identified. The properties of anaerobic sealants have been studied: resistance to temperature changes, chemical resistance, and data on tests of the materials used have been obtained.

During the implementation of the project in 2022:

Work has been carried out to study the basic properties of microsilica fillers, microspheres, and the main characteristics have been determined: granulometric, phase compositions, safety indicators. The study of the structure and properties of waste made it possible to identify patterns in the formation of the structure of materials and design compositions for the development of polymer composite materials. Composite materials based on epoxy resin with different mass contents of microspheres and microsilica have been developed. As a result of the research, a positive effect of microsphere and microsilica fillers on the thermophysical and mechanical properties of epoxy composites was revealed. The tensile and compressive strengths of the composite material increase by 27% and 14%, respectively, and the tensile modulus of elasticity increases by 5% of samples with additives of 2 wt.% of microsilica; with additives of 5 wt.% of microspheres – tensile and compressive strengths increase by 9% and 17%, respectively, and the modulus of elasticity increases by 21%. Impact strength of the composite material with the addition of 2 wt.% microsilica has a maximum value and is 1.187 J/cm^2, which is 1.4-1.9 times greater than the impact strength of standard and composite

materials with additives of 5, 10, 15 wt.% microsilica. And with the addition of 10 wt.% microspheres has a maximum value of 1.411 J/cm^2, which is 1.2-2.2 times greater than the impact strength of standard and composite materials with additives of 2, 5, 15 wt.% microspheres, respectively. The results of the study showed that the microhardness value is observed in composite materials based on ED-20 with additives of 2 wt.% microsilica and 2 wt.% microspheres, and show an increase in the microhardness of the surface of composite materials by 1% and 1.8%, respectively, compared to the standard material.

During the implementation of the project in 2023:

Work has been carried out to develop optimal compositions of composite materials. The structure and properties of polymer composites with additives of optimal amounts of microspheres and microsilica were studied. The properties of the contact zone between the matrix and fillers were studied. The results of studies of the structure and contact zone of the matrix and fillers of polymer composite samples showed that in the presence of additives a dense and homogeneous structure is formed, corresponding to the best strength characteristics of the samples. Samples with the optimal amount of fillers were identified, which showed good connection between the contact zone of the matrix and the filler. Experiments were conducted on chemical stability, resistance to temperature changes, and wear resistance of composite coatings based on epoxy resin with industrial waste additives. During the experiments, an additional significant improvement in the physical and mechanical properties of polymer composites based on epoxy resin was discovered. The optimal amount of fillers that have a positive effect on the processes of structure formation of polymer composites has been identified. An assessment was made of the effectiveness of restoring agricultural machinery parts using composite materials based on polymers, minerals, micro- and nanodispersions. Thus, the goal and objectives set for 2021-2023 have been completed in full.

During the project implementation period (2021-2023) the following were published:

- 2 (two) articles have been published in peer-reviewed scientific publications in the scientific direction of the project, indexed in the Science Citation Index Expanded of the Web of Science database and (or) having a CiteScore percentile in the Scopus database of at least 35 (thirty-five):

1. Serekpayeva M.A., Ibzhanova A.A., Niyazbekova R.K., Kokayeva G.A., Aldabergenova S.S. Properties of Epoxy Resins-Based Composite Materials with the Addition of Microspheres // Chem. Eng. Technol. – 2023. - Vol. 46, No. 6. P.1170–1175. Q2, Percentil: 61. https://doi.org/10.1002/ceat.202200463

2. Kokayeva G.A, Niyazbekova R. K., Serekpayeva M. A, Ibzhanova A. A., Bekeshev A.Z. Using of microsilica for improvement of physical and mechanical properties of epoxide-based composite material // Eastern-European Journal of Enterprise Technologies. Materials Science – 2023. - Vol. 4, No. 12 (124) P.18-25. Q3, Percentil: 47. https://doi.org/10.15587/1729-4061.2023.280474

- 2 (two) articles were published in peer-reviewed domestic publications recommended recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan:

1 Serekpayeva M.A., Kokayeva G.A., Niyazbekova R.K., Kardybai S. Investigation of the properties of composite materials based on epoxy resins with microsilica additives. // Complex use of mineral resources. - 2021. – Vol. 3. No 318. - P.63-70. https://doi.org/10.31643/2021/6445.29

2. Serekpayeva M.A., Niyazbekova R.K., Kokayeva G.A., Ibzhanova A.A., Adilkanova M.A., Bekeshev A.Z., Aldabergenova S.S. Thermophysical properties of epoxy composites with microsphere filler // Bulletin of D. Serikbayev EKTU. - 2023. – No. 3, P.37-44. DOI 10.51885/1561-4212_2023_3_37

- 3 reports were made at scientific forums, including two at international conferences in non-CIS countries with the publication of abstracts:

1. Serekpayeva M.A., Ibzhanova A.A. Analysis of methods of restoration of agricultural machinery parts and corrosion protection // International. sci. - practical conference "Seifullin readings – 18: "Youth and science – a look into the future" / Nur-Sultan, (April 2022). - Vol. I, Part II. Nur-Sultan, 2022. - P.302-305.

2. Serekpayeva M.A., Niyazbekova R.K., Ibzhanova A.A., Kokayeva G.A. Evaluation of defects in agricultural machinery using statistical methods of product quality management // Materiály XVIII Mezinárodní vědecko - praktická konference «Zprávy vědecké ideje». Publishing House «Education and Science» / Prague, (October 22 – 30, 2022).- Vol. 3. Prague, 2022, - P.87-92.

3. Niyazbekova R.K., Serekpayeva M.A., Ibzhanova A.A., Kokayeva G.A.,. Aldabergenova S.S. Physico-chemical Properties of Polymer Composite Materials // Proceedings of Annual Istanbul International Multidisciplinary Conference on Economics, Business, Technology and Social Sciences -2023. Turkey ,13-14 May, 2023. P.25-30.

- 1 patent for a utility model of the Republic of Kazakhstan was received:

1. Utility model patent of the Republic of Kazakhstan No. 2023/0466.2, 04/29/2023. Serikbaeva M.A., Niyazbekova R.K., Bazhanova A.A., Kokaeva G.A. Epoxy composition for protective coating. // Patent for utility model of the Republic of Kazakhstan No. 8520. 2023. Byul. No. 41.