

**ABSTRACT**  
**of dissertation for the degree of Doctor of Philosophy (PhD)**  
**6D072000 – Chemical technology of inorganic substances**

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**Development of energy-saving technology for  
production of prolonged action mechanically activated  
complex mineral fertilizers**

**Actuality of the problem.** Development of competitive chemical industry productions, including production of complex mineral fertilizers, is one of the priority directions specified in “State program on forced industrial-innovative development of the Republic of Kazakhstan for 2010-2014”, and “Program on development of chemical industry of the Republic of Kazakhstan for 2010-2014”. Particularly, there were specified organization of production on output of mineral fertilizers, including nitrogen-phosphoric, not less than 1 million ton a year; on output of complex fertilizers, not less than 200 thousand tons a year; on output of phosphorus-containing fertilizers by acid free technology, not less than 100 thousand tons a year.

Production of phosphorus, phosphoric and phosphorus-containing fertilizers based on the largest fields of phosphorites of Karatau basin is export-oriented branch engaged more than 70% in the export of chemical products (without considering petroleum chemistry) and provides 2/3 of the whole volume of Kazakhstan chemical industry products.

During extraction, reduction and classification of phosphate rock, more than its half passes into phosphate fine coal by fraction of 10 mm. By its granulometric composition it cannot be used for electro-thermal processing, by its chemical composition it is of little use for chemical processing into extraction phosphoric acid. Because of these reasons, the most part of the phosphate fine coal is already stored in the ores' wastes for more than forty years and the problem of the development of new efficient technologies on the processing of off-grade small fraction fines of the phosphate raw material into complex phosphoric and phosphorus-containing fertilizers represents an important scientific, economic and environmental problem.

**Connection with plans of the scientific-research works.** The dissertation work is connected with the plan for carrying out of SRW by grant “Creation of technology and development of scientific bases for synthesis of multicomponent mineral fertilizers with specific characteristics for gray soils” by the program on applied researches of RK MES “Scientific and (or) scientific-technical activity for 2012-2014”, by “Deep processing of raw material and products” priority (State registration No. 0112PK02590) and plans of the state budget SRW of M. Auezov SKSU.

**Object of the research.** The off-grade by granulometric composition and off-sort by chemical composition, phosphate fine coal of Zhanatas field and

mechanically activated phosphoric and complex phosphorus-containing fertilizers of prolonged action.

**Subject of the research.** Processes of mechanical, mechanic-chemical, thermal activation of the phosphate fine coal and technology of mechanically activated complex phosphorus-containing fertilizers.

**Objective and tasks of the research.** Creation of energy-saving technology for production of prolonged action mechanically activated complex mineral fertilizers.

The following tasks were stated for achievement of the objective:

- study characteristics of Zhanatas field phosphate fine coal mineralogical composition and physical-chemical properties;
- study technological and physical-chemical processes of the phosphate fine coal mechanical and mechanic-chemical activation;
- study physical-chemical and technological properties of vermiculite and brown coal as components of the prolonged action complex fertilizers;
- develop process flow diagram for production of the prolonged action mechanically activated complex mineral fertilizers;
- define agro-chemical efficiency of the developed prolonged action complex mineral fertilizers;
- define technical-economic efficiency of the developed technologies.

**Scientific novelty of the research.**

- current methods of physical-chemical researches (DTA, IR spectroscopy, raster electronic microscopy, petrography) have revealed Zhanatas field phosphate fine coal features of mineralogical composition and its structure. A structure of the phosphate fine coal is presented by oolitic grains of phosphates of round and oval shapes in intimate intergrowth with carbonaceous and quartzous cements, small content of argillaceous admixtures. The method of raster (scanning) electronic microscopy has established a distribution character of basic elements of phosphorus, calcium, magnesium, silicon and fluorine in the phosphate fine coal structure. Processes developing during thermal activation of the phosphate fine coal have been studied;

- kinetic content dependences of  $P_2O_5$  citric-soluble forms on parameters of the phosphate fine coal mechanical and mechanic-chemical activation have been established. A mechanism of the processes developing at the phosphate fine coal mechanical and mechanic-chemical activation has been proposed in a result of carried out physical-chemical researches. Ways for intensification of the phosphate grinding and reduction of the mineral fertilizers' caking capacity have been developed.

- vermiculite's physical-chemical and sorption properties allowing provide prolonged action of the mineral fertilizers have been defined. An opportunity to use the brown coal to obtain organic-mineral fertilizer on the ground of activated phosphate fine coal has been studied.

- the principal process flow diagram has been developed and pilot technological line of production of the prolonged action complex mineral

fertilizers allowing plastically vary compositions of the complex mineral fertilizers has been developed;

- agro-chemical efficiency of the developed prolonged action complex mineral fertilizers has been established by field trials;

- technical-economic efficiency of the developed technology of complex mineral fertilizers on the ground of mechanic-chemically activated phosphate fine coal has been defined.

**Conceptual issues, submitted for the defense:**

- characteristics of chemical, mineralogical composition and structure of the phosphate fine coal revealed in a result of the physical-chemical studies provide low activity of oolitic texture fluorine carbonate apatite in traditional processing methods;

- the phosphate fine coal mechanical and mechanic-chemical activation in mills-activators allows significantly increase content of  $P_2O_5$  citric-soluble form, that is connected with physical-chemical changes in the phosphate fine coal structure. Application of surfactants allows intensify the phosphate grinding processes and reduce caking ability of the mineral fertilizers;

- the carried out research has established opportunity to obtain organic-mineral fertilizer on the ground of activated phosphate fine coal and brown coal. It has been established that inflated vermiculite with high sorption properties in the content of fertilizer can carry out a function of the high-absorbency component, at that it increases efficiency and using period of nutritive substances by plants.

- in a result of pilot tests, the opportunity to obtain mechanically activated complex phosphoric and phosphorus-containing fertilizers has been established;

- in carrying out of field tests for the agro-chemical efficiency of the complex mineral fertilizers obtained on the ground of mechanically activated phosphate fine coal, there was achieved increase in productivity of crude cotton from 17.4 c/ha to 22.2-25.4 c/ha, that provided addition to the productivity in 4.8-8.0 c/ha.

- technical-economic efficiency of the developed technologies is provided by the reduction of costs for production of the complex mineral fertilizer and come out at 22257 KZT per 1 ton of product.

**Practical significance of the research.** In a result of the carried out research, optimal technological parameters of the phosphate fine coal mechanic and mechanic-chemical activation were defined, the new energy-saving and non-waste technology for the prolonged action mechanically activated complex mineral fertilizers was proposed. The developed technology is flexible and allows vary content of the complex fertilizer components, wider involve into the production of fertilizers off-grade phosphate raw material. Technical-economic and agro-chemical efficiency of the developed technologies and contents of the complex mineral fertilizers were proved in a result of pilot and field trials.

Three positive conclusions on issue of RK innovative patents for inventions, such as “Production method of capsular slow-acting mineral fertilizer”, “Phosphoric organic-mineral fertilizer” and “Milling method of phosphorus-

containing materials” were obtained for the developed new ways of production and contents of phosphoric and complex fertilizers.

**Personal contribution of the PhD-student** is consisted in analysis and generalization of results of scientific and patent literature analytical researches by the dissertation theme; selection of the research and tests’ methods; carrying out of laboratory experiments, preparing of pilot an field trials, estimation of economic efficiency of the new technology for production of the complex organic-mineral fertilizer.

**Approbation of the research results.** The main results of the thesis work were reported and discussed on international scientific conferences, scientific-technical conferences at enterprises and the scientific organizations, and also on the research workshops of the CTIS Department of M. Auezov SKSU in the period of 2011-2014.

**Publication of the research results.** 18 scientific works were published by the research results by the dissertation work theme, including 7 works (including 2 RK innovative patents, 1 positive conclusions for the issue of RK innovative patents) in scientific editions recommended by RK MES Control committee in the sphere of education and science, 1 works in editions included into “Thomson Reuters” and “Scopus” data base, 1 work in editions included into “Scopus” data base and 5 works in the works of international scientific conferences (3 of them were published abroad), 4 work in other scientific journals.

**Structure of volume of the dissertation.** The dissertation work is composed on 155 pages, contains 35 tables, 51 figures. The work consists of introduction, five chapters, conclusion, list of used sources from 331 names and 10 applications.