ABSTRACT

of thesis for the degree of doctor of philosophy (PhD)
in specialty 6D073100- "Life Safety and Environmental Protection»

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The Process Obtaining of Fire-Explosion Extinguishing Powdering Compounds Investigation of on the Base of Industrial Waste

Relevance of the work. One of the priority areas of life safety and environmental protection is the creation of modified fire and explosion-suppressing powder compositions using of artificial waste of various industries. It possible to reuse sub-standard (overdue) extinguishing agents could have substances that slow down the processes of explosion and combustion of materials.

Fire and explosion-suppressing powders at the end of the shelf life are subject to regeneration or disposal. For the regeneration procedure, i.e. the resumption of fire-extinguishing properties of the powder, it is issue of the manufacturer to restore its properties and characteristics. This allows you to modify the properties of the powder and produce an improved product. At the same time, a significant contribution is made to the development of the system of rational use of natural resources, waste disposal, preservation of the ecological situation of the area, as well as prevention of emergencies and emergencies at industrial dumps.

Complex and rational use of secondary material and raw materials resources and wastes of various industries should occupy a certain place in the raw material balance of the industry and prevention of emergency situations. To date, the share of their use is about 3-5% instead of the estimated 25-30% of the volume of raw materials. Therefore, in the period of industrial and innovative development, the issues of rational and integrated use of man-made waste are of great practical importance.

Although the importance of product reuse has been repeatedly noted both in legislation and in the scientific community, there are currently no comprehensive and systematic methods for assessing and reusing fire extinguishing powders from an environmental perspective. Moreover, the definitions of reuse used in the scientific literature and legislation do not coincide. This thesis presents a classification of different types of reuse, including some proposed definitions. The focus is on recovery issues and the types of reuse in which the used powder (or its components) at least restores the original level of performance. The PhD thesis describes the development of a life cycle assessment method. In addition, various numerical and analytical software tools are used, which model the processes of establishment and testing of the obtained mixtures, in particular, such software products as MATLAB.

In the future, the potential environmental benefits of the recovery of fire and explosion-suppressing powders will be investigated. The mentioned method includes several new aspects: it allows the analysis of possible trade-offs between potential impacts and energy efficiency; simulate some parameters independently that affect the reuse of the product; the method is applicable even on the early stages of the modernization process, if some technical characteristics may not have been defined

yet. The environmental impact of the product life cycle stages is used as input to the assessment.

Environmental protection and prevention of pollution lead to the need for the use of alternative created raw materials from industrial waste for the prevention of emergencies. At the same time, millions of tons of industrial waste in the form of electro-thermal phosphorus slag, phosphogypsum and internal overburden have accumulated at the enterprises of the phosphorus and coal mining industry, allowing to solve the problem of rational use of material resources and pollution in industrial regions.

The importance of rational and integrated use of raw materials in the prevention of emergencies is confirmed by the following factors:

- improvement of the methodology for determining and predicting the fire and explosion-suppressing efficiency of flame-extinguishing powder compositions using MATLAB mathematical and computer modeling;
- investigation of the parameters of expired fire extinguishing powders and the possibility of their further use;
- research of phlegmatizing properties of industrial wastes both for development of new effective flame extinguishing compositions, and for prolongation of service life of substandard powders.
- solution of environmental pollution issues by recycling waste from various industries to release allocated for dumps of cultivated land;
- elimination of harmful effects of pollution of various waste elements into the environment.

Considering this urgent task in the direction of ensuring the safety and life of people, prevention of emergencies in the fires. In addition, waste production has proven itself in obtaining improved fire and explosion-suppressing powders, urgently needed in firefighting.

Object and subject of research. The object of the study is the use of pulverized industrial waste and standard fire extinguishing powders with expired shelf life to ensure the safety of life in emergency situations from fires of different classes.

The subject of research is the composition and simple manufacturing techniques of new fire and explosion-suppressing powders from waste phosphorus production and expired extinguishing powders, as well as their ecological and economic efficiency. In addition, using the proposed computer-mathematical models, it is possible to study and simulate the processes of mixing and flame propagation.

Scientific novelty:

- the suitability of the use of waste phosphorus production and fire-extinguishing powders with expired shelf life as fire and explosion suppressants;
- mathematical and computer model of MATLAB was used to obtain fire and explosion-suppressing powder using fire-extinguishing compositions (as the main component, the expired powder P-2AP was selected, retained the main operational properties) and non-demanded pulverized waste of phosphogypsum and electro-thermal phosphorus slag, which provide sufficiently high operational properties of the compositions at a very low cost;
- the composition of fire and explosion-suppressing powder from a mixture with the following ratios was developed:

composition No. 1 - extinguishing powder based on expired powder P-2AP (73-74,5%) + phosphogypsum (27-25,5%) and
composition No. 2 - extinguishing powder based on expired powder P-2AP (54-57%) + electro-thermal phosphorus slag (46-43%).

Practical significance:

- MATLAB package was used for the simulation of compositions from industrial waste, which allows to improve the environmental condition of industrial regions in Kazakhstan;
- shows the suitability of the use of waste phosphorus production and fire extinguishing powders with expired shelf life as fire and explosion suppressants, which will ensure the safety of life and the prevention of emergencies;
- developed composite powder composition of an expired standard fire extinguishing powders and particulate waste phosphogypsum and electro-thermal phosphorus slag;
- received four International Copyrights on mathematical and computer modeling of the attenuation of the flame in narrow channels, the method of determining endothermic properties of powder materials by differential thermal analysis, Obtaining fire and explosion-suppressing composition on the basis of electro-thermal phosphorus slag and phosphogypsum, Calculation of concentration limits of flame propagation of air-suspended dusts under the influence of certain fire-extinguishing powders are in the publication;
- reducing the cost of fire and explosion-suppressing compositions for multipurpose purposes is achieved using of waste phosphorus production and expired powder;
- the use of waste from various industries in firefighting, as one of the effective measures aimed at ensuring the protection of the environment and conservation of natural resources, flora and fauna;
- the results of the thesis are recommended for implementation in the Educational process for Bachelors and Masters study in specialty "Life Safety and Environmental Protection" in M. Auezov South-Kazakhstan State University:

  1) "Curricula of Fire Safety" – 6 credits;
  2) "Research in Fire Safety" – 6 credits; and
  Elective: 3) "Theory of Combustion and Explosion" – 7 credits;
  4) "Fire safety of public and residential buildings " – 5 credits.

Implementation of work. The results of the PhD Thesis were tested in the Organization "Almaty Zholdary LLP" in the development of fire and explosion-suppressing powder formulations based on electro-thermal phosphorus slag, phosphogypsum and expired powder formulations.

Reliability of research results. The reliability of the research results is confirmed:
- the use of modern methods, instruments and equipment to determine the physical and chemical properties of raw materials and final products in Laboratory (experimental conditions), the volume of experimental studies and consistency of the results of experiments in the same type of samples;

- the mathematical methods and computer modeling for processing of experimental data for the mathematical model of combustion and attenuation of the flame in a narrow channel;
- laboratory experiments with an error of not more than 5% with a degree of correlation of 95%;
- testing of test samples in the field;
- justification of the results in the study of structure formation in the studied materials and acts of introduction into production;
- justification of the results in the study of structure formation in the studied materials and acts of introduction into production;
- correspondence of the obtained graphic and numerical results to Physics and Mechanics of combustion processes under certain conditions, comparison of empirical and numerical results.

The main results:

- method and technology of preparation and fire and explosion-suppressing properties of the powder are determined by absorbed energy in the processes of decomposition and evaporation of the substance, the intensity and width of the cooling range of the flame zone;
- an acceptable estimate of the energy intensity of the powder is achieved by the theoretical method of calculation of the thermal effects of the processes of decay and dissociation of the powder;
- the results of studies of structure formation in the development of mixtures based on phosphorus waste is achieved by the addition of expired serial powders that have retained their fire-extinguishing capacity in the amount of 54-74,5%; at the same time, the cost is significantly reduced and the temperature range of the powder increases;
- computer-mathematical models for calculating the process of mixing powders in different percentages, modeling the propagation and attenuation of the flame in narrow channels under certain assumptions;
- ecological and economic calculations of reducing the consumption of natural resources for the manufacture of new fire and explosion-suppressing powder compositions, using waste phosphorus industry.

Connection with the scientific research. The PhD thesis was carried out in accordance with the research of M. Auezov South Kazakhstan State University, Theme 16-04-03 " Research on the development and creation of innovative technologies for thermochemical enrichment and production of industrial and environmentally safe mineral fertilizers and salts from natural raw materials and artificial waste of various industries".

Approbation of the research. The results of the research were reported and discussed at International scientific conferences: "INDUSTRIAL TECHNOLOGY AND ENGINEERING" (Shymkent, Republic of Kazakhstan), "Scientific research in the modern world", "Vestnik" (Almaty, Kazakhstan), " iScience - MODERN SCIENTIFIC CHALLENGES AND TRENDS" (Warsaw, Poland), "Proceedings of the National Academy of Sciences of the Republic of Kazakhstan" (Almaty, Kazakhstan), "Actual problems of science and education at the present stage" (Almaty, Kazakhstan), V International Conference "ICITE-Industrial Technologies and Engineering" (Shymkent, Republic of Kazakhstan), WASTE-IEEE International

Conference "Management of Municipal Waste as an Important Factor of Sustainable Urban Development" (St. Petersburg, Russia), "ASTESJ - Advances in Science, Technology and Engineering Systems Journal, Special Issue on Advancement in Engineering and Computer Science " (USA).

The personal contribution of the author is:

- selection and development of fire-explosion-suppressing composition of phosphogypsum and internal overburden with the use of waste products of various industries, suppressing combustion and fires of different classes in emergency;
- selection of the composition of materials for obtaining fire and explosion-suppressing composition of waste phosphorus production;
- physico-chemical, IR spectral and X-ray phase analysis of fire and explosion-suppressing materials;
- theoretical and experimental study of the endothermic efficiency of expired powders and experimental tests on the development of compositions of fire and explosion-suppressing materials to improve the efficiency of fire-extinguishing properties, allowing to prevent and eliminate emergencies;
- presentation of the most detailed classification of combustion and explosion phlegmatizers by their mechanisms;
- development of the technique with sufficient reliability to define efficiency of replacement of natural resources on waste of various productions and overdue standard powder structures and a rational ratio of components in multipurpose fire-explosion-suppressing mixes.

Publications. The main results of the PhD thesis were published in 16 scientific publications, including 2 scientific articles notices by Scopus/Web of Science (Thomson Reuters), 4 articles in Journals recommended by Committee for Control in Education and Science of MES RK, 4 Proceedings of International Conferences, 2 Proceedings of Conferences.

4 (Four) Authorized Copyrights are issued: the Method of determining the endothermic properties of powder materials (no. EU-01-001629 dd 28.03.2018, Berlin, Germany), Mathematical and computer modeling of flame attenuation in narrow channels (no. EU-01-001884 dd 15.08.2018, Berlin, Germany), Obtaining fire and explosion-suppressing composition on the basis of electro-thermal phosphorus slag and phosphogypsum (no. EU-01-002539 dd 04.11.2019, Berlin, Germany), Calculation of concentration limits of flame propagation of air-suspended dusts under the influence of certain fire-extinguishing powders are in the publication(no. EU-01-002539 dd 04.11.2019, Berlin, Germany).

Structure of the PhD Thesis. The thesis consists of 5 sections, the main conclusions, a List of references and Applications. The main content of this work is presented on 166 pages and includes 72 figures and 46 tables.