ABSTRACT

For the dissertation work for the degree of Doctor of Philosophy (PhD) in the specialty 6D073400/8D07103 – "Chemical technology of explosives and pyrotechnics"

TURSYNBEK SABIT

Chemistry and physics of gas generator cartridges based on deflagration combustion

General characteristics of the work. The dissertation is devoted to the development and research of new gas-generating compositions based on sodium nitrate, magnesium and activated carbon from a gas mask and activated carbon from a walnut shell as additives of gas-forming agents.

Thermodynamic calculations of combustion gas generator compositions parameters were carried out to determine the optimal content of the initial components of pyrotechnic gas generator compositions. Experimental studies of combustion processes have been carried out and formulations of gas generating compositions with subsonic burning speed and the most efficient performance and high specific gas production have been developed. Field tests of the developed patronized gas generator compositions were carried out to determine the possibility of their application in practice.

Relevance of the research topic. As is known, most solid minerals are deposited in rocks that require the use of explosive technologies; the gentle technology (careful blasting) of their extraction is of particular relevance. The use of high-density traditional explosives for ore deposits leads to the formation of microcracks, which prevents the use of valuable crystal raw materials for their intended purpose. The use of high-density high explosives is also accompanied by the formation of seismic and shock air waves, the scattering of individual rock fragments over considerable distances.

To reduce the explosive effect of the explosion, various types of reduced charges, low-explosive explosives, non-explosive destructive mixtures, soft-loading charges with water and air gaps are used, providing a quasi-static effect on the rock. The choice of a certain type of action depends on the properties of the breed. Recently, gas-generating charges have been used in the extraction of minerals, creating pressure in the cavity of the charging chamber due to the combustion reaction in the deflagration combustion

Based on the above, the development of low-density patronized gas-generating compositions operating in deflagration mode with gentle blasting is of particular relevance. When using low-density gas-generating compositions, the formation of harmful, poisonous gases and the explosive effect of an explosion, expressed in the

formation of seismic, shock air waves and the scattering of individual rock fragments, are practically excluded.

The purpose of the work. The purpose of this dissertation is to develop the scientific foundations for the creation of patronized gas generator compositions having subsonic combustion (deflagration) and high efficiency, which can be applied without adding additional components in the field for splitting in a gentle mode of block stone or destruction of solid mineral rocks.

Tasks of the work. To achieve this goal, the following tasks were solved:

- performing thermodynamic calculations of combustion parameters of gas generator compositions in order to select the optimal content of the initial components of gas generator compositions, ensuring their high energy efficiency;
- performing physico-chemical analyses to determine the macro and microstructure of the initial components and combustion products;
- development of formulations of gas-generating compositions based on sodium nitrate, magnesium and carbon and laboratory tests to control combustion modes with subsonic speed and evaluate the performance of the proposed formulations combustion;

conducting field studies using the developed patronized gas generator compositions; evaluating the effectiveness of the proposed formulations.

The main provisions to be defended:

- the results of thermodynamic calculations of combustion parameters of gas generator compositions to determine the optimal content of the initial components of gas generator compositions;
- results of the study of combustion with subsonic burning speed of the developed gas-generating compositions based on sodium nitrate, magnesium and carbon, evaluation of the operability of the compositions;
- formulations of patronized gas-generating compositions based on sodium nitrate, magnesium and carbon, operating in the mode of deflagration gorenje in open-pit mining, virtually eliminating the explosive effect of the explosion;

The results of the conducted landfill studies, developed patronized gas generator compositions, indicating the high efficiency of the proposed compositions.

Objects of research. Pyrotechnic compositions consisting of sodium nitrate, magnesium and, as additives of gas-forming agents, activated carbon from a gas mask and carbonized carbon from a walnut.

Subject of research. The main laws of gorenje gas generator compositions based on sodium nitrate, magnesium and carbon and the possibility of their use for the destruction of artificial objects and rocks.

Research methods. When solving the tasks necessary to achieve the goals, the following research methods were used: thermodynamic calculation using the Terra program, thermogravimetric analysis, combustion method, X-ray phase analysis, scanning electron microscopy, method for determining the combustion temperature, landfill studies, chromatographic analysis to determine the composition of gaseous products.

Scientific novelty of the research. The following results were obtained for the first time in the work.

- On the basis of thermodynamic calculations, the influence of the ratio of the initial components on the efficiency of combustion products (gunpowder strength, RT) and the specific gas production of gas generator compositions has been studied. It is established that high efficiency and specific gas production are observed at the ratio of the initial components 60% - NaNO3, 20% - Mg, 20% - C;
- combustion characteristics of the proposed gas-generating compositions based on sodium nitrate have been studied. combustion was found to have a burning rate of 3-5 mm/sec. and the flame temperature is 2000-2500 K. The powder strength is 614 kJ/kg, the gas capacity is 4.8 m3/kg.
- Physico-chemical analyses were carried out for the initial components and for combustion products of the compositions. The dispersion of carbon, which provides layer-by-layer combustion of the charge, is determined combustion. This corresponds to particle sizes in the range of 100-200 microns. According to the results of X-ray phase analysis of solid combustion products, it was found that the main products are magnesium oxide and sodium carbonate;
- According to the results of laboratory tests of the gas generator composition, it was found that the deflagration mode of combustion occurs without transition to detonation. The maximum pressure during the 4.5 MPa.;
- Based on the results of landfill tests, it was found that the developed patronized gas generator compositions based on sodium nitrate and carbon can be successfully used in open-pit mining operations for splitting block stone in a gentle mode or destroying solid mineral rocks with a strength coefficient from 4 to 14 according to Protodyanokov.

Theoretical significance. The article presents scientifically based criteria determining the choice of the component composition of patronized gas generator compositions, as well as technological processes and optimal conditions for the extraction of mineral raw materials using gas generator compositions in conditions of open-pit mining and variation of mine materials depending on the composition of the initial components, the stage of metamorphism, storage methods, etc.

Practical significance. As is known, most of the precious stones are deposited in rocks that require the use of explosive technologies, while the gentle technology (careful blasting) of the extraction of precious stones is of particular relevance. The use of high-density traditional explosives in the conditions of ore deposits leads to the formation of microcracks, which prevents the use of valuable crystal raw materials for their intended purpose. Therefore, the development of low-density patronized gas-generating compositions operating in deflagration mode with gentle blasting becomes relevant. When using low-density gas-generating compositions, the formation of harmful, poisonous gases and the explosive effect of an explosion, expressed in the formation of seismic and shock air waves and the scattering of individual rock fragments, is completely excluded. In this regard, in this work, patronized gas-generating compositions based on sodium nitrate, magnesium and carbon were developed, operating in the mode of deflagration gorenje and virtually eliminating the explosive effect of the explosion, manifested in the form of SVV and UVV, as well as in the form of the scattering of small fragments.

The developed gas generator compositions have high energy characteristics and can be used for efficient processing of certain types of mineral and natural raw materials in the ore deposits of Kazakhstan.

Approbation of the work. The materials of the dissertation work were reported and discussed at various international symposiums and foreign conferences:

- Joint VIII International Symposium " Combustion and plasmochemistry" and scientific and technical conference "Energy Efficiency-2019" (Almaty, Kazakhstan, November 20-22, 2019);
- IX International Symposium "Physics and Chemistry of Carbon Materials/Nanoengineering" and the International Conference "Nanoenergy Materials and Nanoenergy" (Almaty, September 12-14, 2018);
- Proceedings of the W International Russian-Kazakh Scientific and Practical Conference "Chemical Technologies of Functional Materials" (Novosibirsk, Russia, April 27-29, 2018);
- IX International Symposium " Combustion and plasmochemistry " (Almaty, September 13-15, 2017).
- Forum on the Development of Functional Materials and Technology between China and the CIS countries (Nanjing, China, September 18, 2023).

The author's personal contribution. Consists in setting up and conducting experiments, determining methods of analysis and ways to solve practical and theoretical problems, generalizing and interpreting the results obtained, writing articles and reports.

Publications. The main results of the dissertation work have been published in 12 publications, including 1 article included in the Scopus database; 4 publications

have been published in publications recommended by the Committee for Control in the Field of Education and Science of the Republic of Kazakhstan, 7 – in collections of international symposia and foreign conferences.

The scope and structure of the work. The dissertation work is presented on 99 pages and includes 40 figures and 9 tables. The work consists of an introduction, a literature review, a description of the objects and methods of research, the results and their discussion, a conclusion and a list of sources used, including 158 titles.

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