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Development of industrial explosive reducing man-caused impact on the environment

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Abstract

Development studies of nitrateammonium industrial explosive (IE) reducing man-caused impact on the environment during mining are presented. For providing of waterproofness, ammonium nitrate prills were primed by nitrate cellulose or conversion blasting powder, not suitable for further usage for the purpose specified. By thermodynamic calculation it was stated the correlation of ammonium nitrate and primed coating of commercial explosive, providing the absence of toxic fumes in explosion products. Introduction of coating of surface-active materials allowed to eliminate static characteristic of industrial explosive and to make it save at spilling and loading of chinks even by pneumatic transport. New industrial explosive is waterproof, does not form toxic gases at explosive conversion, does not electrify at spilling and transportation, that provides ecological security of its usage.

Key words: ECOLOGICAL SECURITY, INDUSTRIAL EXPLOSIVE, GASEOUS PRODUCTS OF EXPLOSION, WATERPROOFNESS, STATIC CHARACTERISTIC

Ecological security when applying industrial explosive for mining is relevant task in mining industry all over the world. Productive activity of metallurgical and mining complex affects greatly environment. At explosive conversion of high energy systems, millions of tons of harmful substances are wasted into atmosphere, millions of cubic meters of polluted wastewater are thrown into water, and huge amount of solid wastes are stored on the top of the ground.

The main industrial explosives used both in Ukraine and abroad, are nitrate ammonium and tolite-containing ones. During application of tolite-containing industrial explosives there forms up to 115 l/kg of carbonic oxide [1, 2]. This substance is very toxic, as it is dangerous not only for air ecosystem but also for a human. During longtime contact of operating personnel with small

concentration of carbonic oxide, poisoning is possible, which may lead to fainting. Carbonic oxide affects human's cerebral cortex, provokes irreversible nervous system disorder. Besides tolite, which is included as coating of ammonium nitrate prills, such IE as grammonite 79/21 GS is dielectric. Pneumatic loading of granulated CE, containing tolite, is followed by intensive electrification of the IE flow, herein electrostatic energy is 52.8mJ at minimum ignition energy of grammonites 1.05 mJ. That is why electrification phenomena should be considered during manufacturing and application of explosives, as it may lead to striking of spark and non-planned explosion during exploitation of IE.

Analysis of existing literary sources showed that existing industrial explosives on the base of ammonium nitrate have the following disadvantages:

-pollute the atmosphere by toxic gases exceeding the norms of ecologically permissible concentration;

- low water resistance (exept emulsive IE), which is followed by pollution of ground ecosystem by ammonium nitrates;

- low energetic characteristics;

- low chemical and physic constancy;

- granulated IE is tended to electrification, which increases the possibility of explosions during their storage, usage at transportation;

- emulsive IE is used for loading of chinks only in hot condition, that determines their usage just after manufacturing;

- granulated IE with coating is brittle, breakaway, dust, increasing man-caused load on the environment.

It is possible to create balance between ecological aspects and increased explosive characteristics of IE by means of creation of new waterproof nitrate ammonium IE, which would not have these disadvantages. That is why for environmental security, high water resistance, energetic characteristics and absence of post-detonation toxic fume and electrification during usage, security of high strength as coating of ammonium nitrate prills, high-powered material - nitrate cellulose is chosen [3].

At this stage of industrial development utilization of non-effective armament [4] is fulfilled by means of outdoor burning, which is followed by emission of great amount of nitrogen oxides and carbon. Creation of IE on the base of nitrate ammonium and conversion nitrate cellulose powder explosive provides not only water resistance and high explosive characteristics but also allows to reduce man-caused load on the environment by means of processing of utilizable powders explosive into ecologically clean industrial explosive.

Researches concerning application of colloxylins, conversion pyroxiline and ballistit powders and also ballistite rocket fuel as a composite of nitrate ammonium IE are presented. For reduction of air pollution by post-detonation toxic fume of IE, system oxygen balance was preliminary calculated. For calculation of oxygen balance of the mixture, molecular number of components was calculated:

- ammonium nitrate (AN) (NH_4NO_3) with 80 molecular number and +20% oxygen balance;
- BP NDT-3 ($C_{23.00}H_{30.00}N_{10.00}O_{34.00}$) with 990.00 molecular number and -44% oxygen balance;

Industrial powder explosive (IPE) ($C_6H_{7.55}N_{2.45}O_{9.9}$) with 272.25 molecular number and - 38% oxygen balance.

Composition of nitrate ammonium CE with zero oxygen balance contains: 66% AN and 34% IPE; 69% AN и 31% BP or ballistite rocket fuel RSI-12K. Industrial explosive under development is called ammoporom –W [5]. In order to determine amount of gas and thermodynamic characteristics, which is evolved during explosive conversion of IE, there were fulfilled researches in accordance with multi-purpose program "Astra" – "Modeling of chemical and phase equilibrium at different temperatures" and Avakyan methodology .In the base of "Astra" program lies universal thermodynamic method for determination of characteristics of heterogenic systems balance; these systems are based on the basis of maximum entropy. The program allows to calculate the amount and composition of combustion gases. Research results are presented in the table 1.

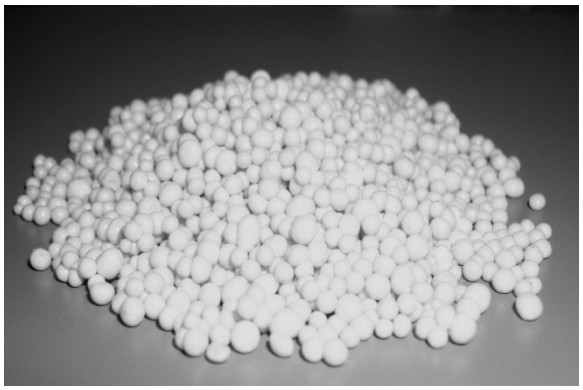
Table 1 thermodynamic characteristics and gas composition of IE

Indicator name	Values	
	Ammoporom –W	Tolite-containing IE

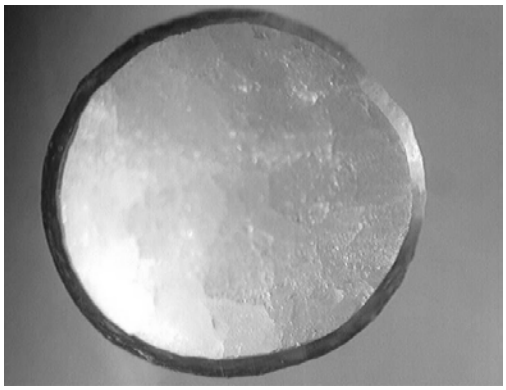
Entalpy H_s, kJ/kg	952.96	44.49
Acidity coefficient, A	101.58	36.36
Coefficient of sales, K %	0.97	0.76
Oxygen balance, %	0.91	-74.01
Heat capacity, cal/mole	149.18	86.68
Explosion heat, kcal/kg	916 - 925	985
Gas volume, l/kg	909 - 920	785
Explosive temperature, K	2642 - 2705	2869
Fougasseness, ml	316	307
Detonation velocity, м/с	5400	4250
Pressure Pr, kg/sm^2	59509	58282
Gas composition	Amount of gas, mole/kg	
	Ammoporom –W	Tolite-containing IE
H_2O	21.91	20.36
CO_2	5.25	6.38
CO	0.00	14.78
C	0.00	14.41
H_2	0.01	2.66
N_2	6.86	10.56
O_2	2.2	1.91
NO	0.4	3.06

Calculations showed that ammoporom –W has high explosive characteristics, and also during its explosion toxic gases are not formed. Gas composition of explosion products is exposed mainly by H_2O steams, CO_2 and N_2 bioxyde, which are provided by zero oxygen balance.

When applying most of nitrate ammonium explosives in wet holes, there take place scavenging and accumulation of AN in subsurface water and quarry cracks, which pollute them. For lowering of man-caused impact on the environment with the help of device with fluidized bed, laquer on the base of utilized powders, saluted in acetic ether, was applied on the ammonium nitrate prills for formation of firm waterproof jacket. Physical form of commercial explosive and section of ammoporom –W granula are shown in the figure 1.



a



b

Figure 1 Physical form of IE a; section of ammoporom –W granula, 120^{x} magnification range – b.

For determination of degree of coating water perviousness special methodology is developed [6]. This method allows to determine water resistance of films at different pressures, from air pressure to 2 kg/sm^2, and also within temperatures from 18^{o}C to 40^{o}C. This is connected with the necessity of IE application in underground conditions, where increased temperatures and pressures are possible. Increased pressure imitates water flowage.

Research of characteristics of coating on the AN granules is complicated. That is why at technological mode of IE production, nitrate rayon laquer was applied on the glass or plastic plates in order to get the film in the form of sheet material. For reliability of data, density of coating and film was determined. Density of nitrate rayon film and IE coating, which was determined by volume-weight method, was similar and made 1.46 (±0.01) g/sm^3.

Research results represented in the form of characteristic curves in the figure 2.

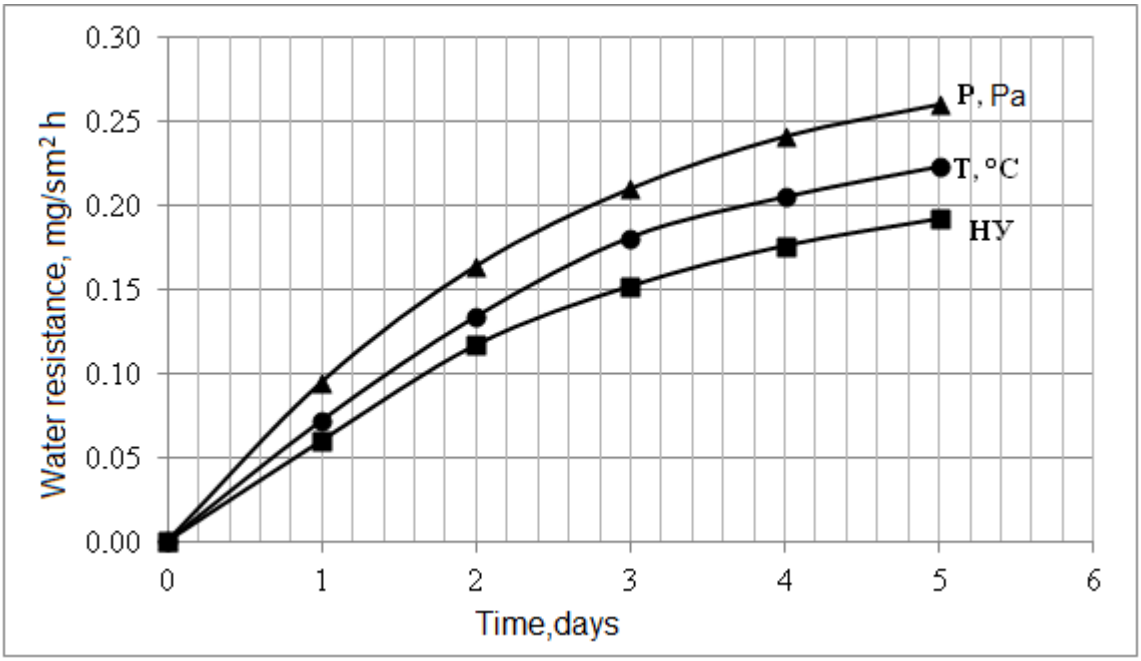


Figure 2 Dependence of water resistance of nitrate rayon film on holding time in the water:
■ – at atmospheric pressure and temperature 18^{o}C;
● – at atmospheric pressure and temperature 40^{o}C;
▲– at pressure 1.5 kg/sm^2 and temperature 18^{o}C.

It follows from the figure 2 that increase of the temperature and pressure contributes acceleration of diffusion processes of water molecules penetration through nitrate rayon film.

Operating IE grammonite 79/21 GS has coating on the base of tolite with low strength characteristics, up to 1.2 kg/sm^2. Coating may crack when granules contact with each other, also destroy and peel while exploitation, these provokes man made danger while application of grammonite 79/21, considering its high static characteristic. Nitrate rayon coating ammoporom –W has the strength up to 20 kg/sm^2, that is why it is not destroyed.

To reduce its static characteristic, 0.1-0.2% of surface-active substance, such as polyoxyethylene allylphenol ethers of OP-4, OP-7 or OP-10 type were included. Volume resistivity of IE reduced from 10^8 Ohm·m to10^4 Ohm·m, i.e. ammoporom –W was changed from dielectric to conductor. Absence of ammoporom –W static characteristics provides its save exploitation even during pneumatic conveying and pneumo-loading of holes, which is particularly topical during blasting workings connected with iron ore crop in underground conditions of Kryvyi Rih region.

Developed nitrate ammonium industrial explosive will reduce man-caused impact on the environment by means of:

- processing of conversion and ballistit powders, rocket fuels, being accumulated in Ukraine and presenting ecological threat for natural environment;
- lowering of solvability of nitrate ammonium that will provide reduction of ground-water ecosystem pollution during blasting workings;
- reduction of emission of toxic gaseous products during blasting workings connected with mining;
- exception of accumulation of static charges on the IE surface, excluding man-induced disaster during spilling, transporting and loading of holes.

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