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PECULIARITIES OF MANUFACTURING AND APPLICATION OF MIXED EXPLOSIVES OF ANFO TYPE AT MINING ENTERPRISES OF MONGOLIA

Vladimir A. BELIN[1], **Gennadii P. PARAMONOV**[2], **Jijig JAMIYAN**[3]
[1] *Mining Institute NUST MISIS, Moscow, Russia*
[2] *Saint-Petersburg Mining University, Saint-Petersburg, Russia*
[3] *MonMag LLC, Ulaanbaatar, Mongolia*

The article describes problems of blasting operations carried out at an industrial scale using ammonia-nitrate explosives. Based on experimental studies conducted by the authors, it was determined that for use in mining enterprises in Mongolia, primarily in coal mines, the most rational and effective explosives are mixed ones based on ammonium nitrate in the solid state with various liquid as well as solid dispersed fuels additives - ANFO mixtures. The temperature boundaries for the phase transitions of ammonium nitrate in open areas for the period of three months for different humidity values have been determined. The indicators of oil absorption are identified depending on the cycle of phase transitions for ammonium nitrate.

Key words: ammonium nitrate; blasting operations; phase transitions; crystal lattice; fuel oil, granules

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Introduction. In natural conditions, ammonium nitrate (AN) is in a solid crystalline state, the specific shape of the particles is determined by the manufacturing technology and the conditions of subsequent storage.

The AN crystal lattice can have five different patterns. With modification transformations, the volume and density of crystals change. Strength of crystals and AN granule depends on the production process during manufacturing and the number of modification transformations to which they can be subjected during the storage of the product.

To obtain explosives based on mixtures of ANFO in Mongolia, it is necessary to consider AN preliminary preparation and technology for manufacturing ANFO mixtures taking into account the destructive processes occurring in the AN. However, the «direct» use of mixtures of ANFO known and used in other countries, including Russia, is impossible at mining enterprises in Mongolia due to the specific conditions of raw materials supply, which is oriented to the purchase of almost all components abroad.

It is known that in the composition of mixed explosives, ammonium nitrate acts as an oxidizing agent [3, 4]. The combustible component for mixed explosives could be made from any substances capable of oxidation and having a negative oxygen balance. The most convenient for purchasing, transportation, processing, safety, etc. are liquid petroleum products, in particular fuel oil (FO) and mineral oils.

Methods of research and discussion of the results. Based on experimental studies carried out by the authors [2, 6, 7], it was determined that for mining enterprises in Mongolia, primarily in coal mines, the most rational and effective are mixed explosives based on ammonium nitrate in the solid state (in granular form) [10, 11] with various liquid as well as solid dispersed combustible additives – mixtures of the ANFO (igdanite) type.

The composition of mixed explosives is arranged so that the amount of oxygen in the mixture corresponds to the number of combustible components and ensures their oxidation to the total oxides [5]. With this ratio, the oxygen balance of the explosive is zero. In existing natural conditions, ammonium nitrate is in a solid crystalline state, the specific shape of the particles is determined by

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the manufacturing technology and the conditions of subsequent storage. The most convenient for practical use is the state of the AN in the form of granules having the size from tenths of a millimeter to several millimeters.

The physical nature and state of the AN determine another characteristic disadvantage of mixtures of granular AN with liquid combustible additives, it is the complexity, sometimes the impossibility of obtaining stoichiometric mixtures of AN and FO that are uniform in composition and stable in time. In practice, this is manifested in the fact that the upper part of the charge from the mixture of ANFO has a lack of fuel (a positive oxygen balance) and explodes with a decrease in energy release and an increase in the yield of toxic nitrogen oxides. The lower part of the charge has an excess of fuel (negative oxygen balance) with increased release of toxic carbon oxides and low energy release during the explosion. The resulting system gives negative results on the effectiveness of mixtures of the ANFO type in blasting operations.

Ammonium saltpeter (ammonium nitrate) is a polymorphic crystalline substance. When the temperature is lowered from 169.6 °C (melting point of the AN) to –18 °C, or vice versa, with an increase within this range, the AN lattice can have five different structures. With modification transformations, the volume and density of the crystals change [1, 9] (Fig. 1, 2).

Strength of crystals and AN granule depends on the production process during manufacturing and the number of modification transformations to which they can be subjected during the storage of the product. With repeated modification transformations, in particular, when passing through the temperature point 32.2 °C (modification transition III-IV-III), which is possible under real operating conditions with AN, the AN granules are characterized by a large change in the volume of the crystals and some cracking. With the cracking of the granules (Fig.3), their absorbency with respect to petroleum products increases, but the strength decreases. This phenomenon makes it very difficult to obtain stable mixtures of ANFO in the real mining conditions.

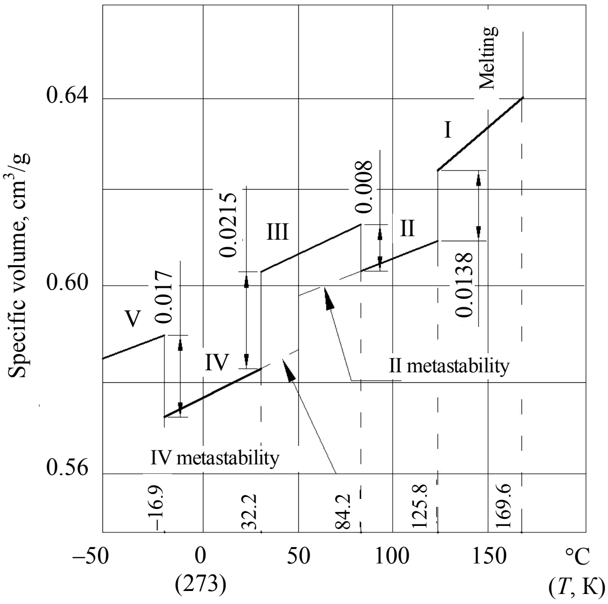

Fig.1. Dependence of the specific volume of ammonium nitrate from the temperature at phase transitions in standard conditions

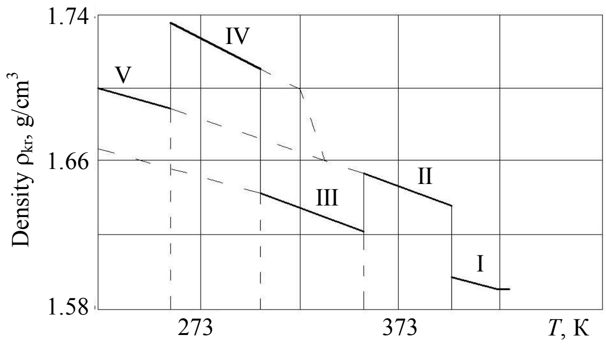

Fig.2. Dependence of ammonium nitrate density from the temperature at phase transitions in standard conditions

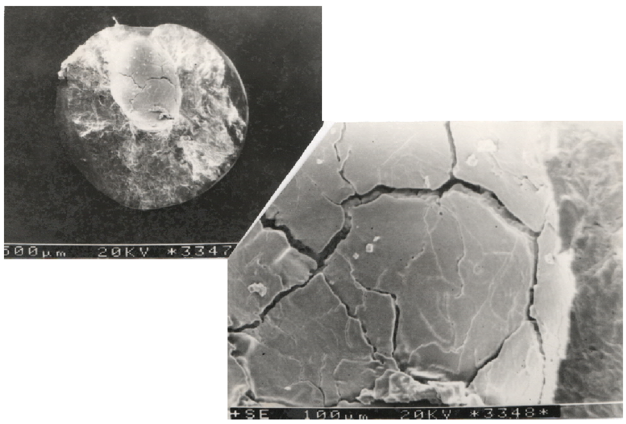

Fig.3. Changes of saltpeter granules structure during phase transition

The experience of ANFO manufacturing in Mongolia shows that because of storing ammonium nitrate under conditions of extremely continental climate and active ultraviolet radiation (the main part of the country is at an altitude of

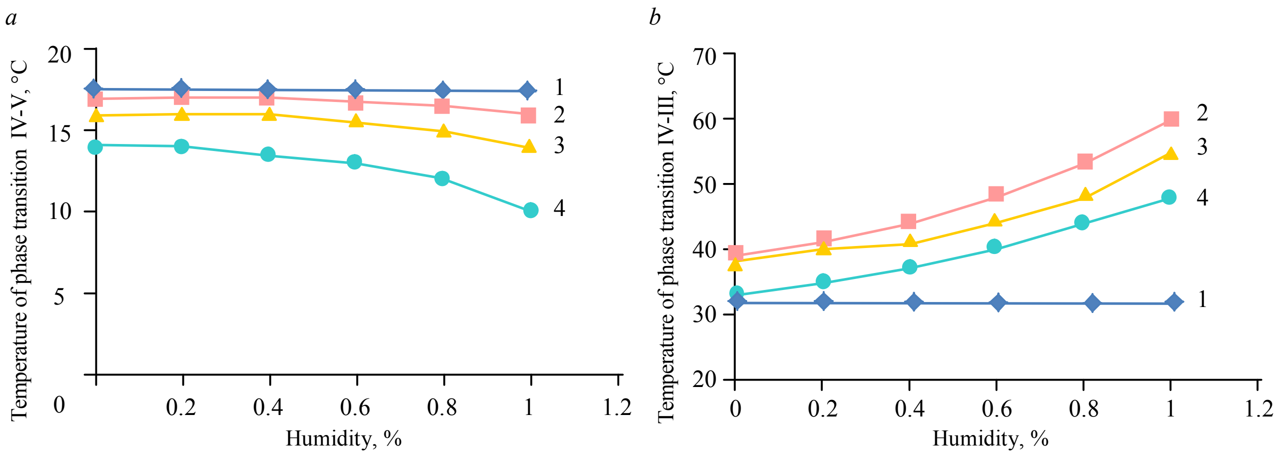

Fig.4. Changes of temperature limits of AN phase transitions IV-V (*a*) and IV-III (*b*) under conditions of Mongolia at different humidity and storage time for granules

1 – standard value; 2 – 1 month; 3 – 2 months; 4 – 3 months

1000-1200 m above sea level, the sunny weather prevails more than 300 days a year, the humidity of saltpeter does not exceed 1.0-0.35 %), the temperature phase transitions significantly differ from the standard values.

To determine the numerical values of the AN phase transitions in Mongolia, we conducted a laboratory study of the temperature boundaries of phase transitions for saltpeter exposed to ultraviolet radiation in an open area for 3 months in the temperature regimes corresponding to phase transitions (Fig.4)

During production of ANFO mixtures ammonium nitrate in the form of dense granules retains not more than 2 % [8] of liquid fuel, which is not sufficient to isolate the maximum explosion energy of this composition. In this case, many nitrogen oxides, which have a significant toxic effect, are released. Phase transitions lead to the destruction of saltpeter granules, the appearance of discontinuities in the surface of the granules (see Fig.2), the formation of internal cracks and an increase in the retention capacity of saltpeter to 12 %, which multiply exceeds the stoichiometric ratio.

Depending on the conditions and time of storage of saltpeter, its destruction takes place uncontrollably and unevenly in volume, which leads to the formation of an explosive charge in the form of a «layered pie» with different detonation characteristics. The manufacture of ANFO mixtures under such conditions can cause incomplete detonation or burn-out of a part of the charge due to excess or lack of liquid fuel. In this case, the products of combustion and detonation are the following: carbon, carbon oxide and nitrogen oxide (Fig.5). With excess of liquid fuel, it deters the components of explosives. Consequently, during the explosion, we have downhole charges with various uncontrolled detonation characteristics, which greatly influences the safety and efficiency of blasting operations.

Fig.5. A photo of ANFO mixture (layered pie type) blasting charged by mixing-charging machine at Baganuur deposit

Therefore, for production of explosives based on ANFO mixtures in Mongolia, we need to have preliminary preparation of the AN and technology for making ANFO mixtures, considering the destructive processes occurring in AN.

Conclusion. The results of experimental studies have shown that a single heating of ammonium nitrate up to a temperature above the phase transition temperature III-

IV (about 32.3 °C) makes it possible to increase the oil absorption coefficient of granulated AN relative to FO up to 4.5-5 %. This is still not enough to obtain a completely stable balance of the oxidant-fuel mixture, but significantly improves the quality of the ANFO mixture of a porous AN compared to the mixture of the initial granular nitrate. Based on results of large number of tests and observations, it was established that in the implementation of a single cycle of phase transitions IV-III-IV, the oil absorption coefficient increases by 25-30 % compared to the value for the initial AN.

Double heating of a high-density AF results in a more than 6 percent increase in the retention capacity of the product relative to FO, which will ensure the production of stable explosive mixtures of stoichiometric composition, increase the quality and safety of blasting operations.

The implementation of this technological process should be assessed from technical and economic point of views considering the specific features of a particular mining enterprise.

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***Authors*: Vladimir A. Belin,** *Doctor of Engineering Sciences*, *Professor*, *bvamggu@mail.ru* (*Mining Institute NUST MISIS*, *Moscow*, *Russia*), **Gennadii P. Paramonov,** *Doctor of Engineering Sciences*, *Professor*, *paramonov@spmi.ru* (*Saint-Petersburg Mining University*, *Saint-Petersburg*, *Russia*), **Jijig Jamiyan,** *General director*, *savmon@inbox.ru* (*MonMag LLC*, *Ulaanbaatar*, *Mongolia*).

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