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Calsium-Ammonium Nitrate Based on Dolomite Mineral, Phosphogypsum, Ammonium Nitrate and Sulfate

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ABSTRACT: In the article, FG obtained by adding phosphogypsum (FG) in the amount of 3-10% of its total mass to the dolomite-nitrate fluid created by adding dolomite mineral (DM) AS : DM = 100 : 3 to 100 : 45 by weight ratio to ammonium nitrate (AS) fluid the composition and some properties of samples of saltpeter with added lime-alloy were studied. According to it, it was determined that the strength of the obtained samples increased by 2-4 times, viscosity, porosity and diesel fuel absorption decreased by 2-3 times compared to pure AS grains.

KEYWORDS: Ammonium nitrate, dolomite mineral, phosphogypsum, magnesium lime-ammonium nitrate, composition, grain strength, viscosity, porosity and diesel absorption.

I.INTRODUCTION

Ammonium nitrate (AN) is the most common and effective nitrogen fertilizer in the world. In 2007, its global production capacity amounted to 43 million tons per year [1]. In Uzbekistan, the total capacity of three plants producing ammonium nitrate (JSC Maksam-Chirchik, Navoiazot and Ferganaazot) exceeded 1 million 750 thousand tons per year. It is used in agriculture for all types of crops and on all types of soil. But it has one very serious drawback - explosiveness [2]. In this regard, the requirements for the quality of the AU and the conditions for its storage were tightened. Manufacturers have been given the task of ensuring the transition to the production of fertilizers based on ammonium nitrate, which retain agrochemical efficiency, with significantly greater resistance to external influences and, accordingly, less explosion hazard.

As substances - additives that reduce the level of potential hazard of ammonium nitrate, the following are used:

1) carbonate-containing compounds of natural and technogenic origin (chalk, calcium carbonate, dolomite);

2) potassium-containing substances (potassium chloride and potassium sulfate);

3) substances containing the cation of the same name - ammonium (ammonium sulfate, ammonium ortho- and polyphosphates);

4) other ballast substances that do not carry a payload, but determine only the mechanical dilution of ammonium nitrate (gypsum, phosphogypsum, and others) [3].

Additives of the first group are used in the production of the so-called lime-ammonium nitrate (IAS) [4]. In Europe, it is produced by 31 firms, in Russia - by five industrial enterprises.

Of the substances - additives of the second group, potassium chloride is widely used for the production of potassium-ammonium nitrate. In Russia, the production of nitrogen-potassium fertilizer based on ammonium nitrate and potassium chloride was first mastered at OAO Nevinnomyssky Vneshtreidinvest in 1999. The method of production and composition of the fertilizer are protected by a patent of the Russian Federation [5].

Substances - additives of the third group were used at OAO "Cherepovets Azot", where in 2002 the production of stabilized ammonium nitrate with a composition of 32% N and 5% P_2O_5 was launched with a capacity of 400 thousand tons of fertilizer per year by introducing a liquid complex fertilizer containing 11% N and 33% P_2O_5 and obtained from superphosphoric acid, that is, an additive from a mixture of ammonium ortho- and polyphosphates was used. This additive increased the temperature of the beginning of saltpeter decomposition by 22–24°C, slowed down the rate of its thermal decomposition, increased the strength of the granules, reduced the porosity of the product, made the saltpeter more

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resistant to repeatedly repeated phase transformations, and most importantly, reduced the ability of saltpeter to detonate [6–9] .

Representatives of the fourth group of additives to ammonium nitrate are also promising: gypsum and phosphogypsum [10–12]. In these works, a technology was developed for obtaining a thermostable fertilizer based on AS by introducing dihydrate, phosphogypsum hemihydrate and natural gypsum into its melt. The resulting product with a 5% addition of phospho hemihydrate and containing 33,6% N had twice the strength of the granules than pure saltpeter, retained 100% friability for 4 months, withstood 7 thermal cycles at temperatures of 20–60°C without significant reduction in the static strength of the granules, had a weaker solubility compared to pure nitrate. The product had a significantly higher thermal stability compared to pure ammonium nitrate (activation energy for pure nitrate 160 kJ/mol; with the maximum amount of phosphogypsum added was 240 kJ/mol).

We decided to test the process of obtaining calcium ammonium nitrate based on AS by introducing two promising additives into its melt at once - dolomite mineral (DM) and phosphogypsum (PG) from the production of extractive phosphoric acid at the Almalyk JSC "Ammophos-Maxam". Over 80 million tons of FG have accumulated in the dumps of this plant.

II. SIGNIFICANCE OF THE SYSTEM

In the article, FG obtained by adding phosphogypsum (FG) in the amount of 3-10% of its total mass to the dolomite-nitrate fluid created by adding dolomite mineral (DM) AS:DM=100:3 to 100:45 by weight ratio to ammonium nitrate (AS) fluid the composition and some properties of samples of saltpeter with added lime-alloy were studied. The study of methodology is explained in section III, section IV covers the experimental results of the study, and section V discusses the future study and conclusion.

III. METHODOLOGY

As initial components, we used pure AS (34.96% N), crystalline DM whose complete chemical composition of the sample is given in Table 1.

Table 1.
Chemical composition of dolomite from the Shorsu deposit, Fergana region.

Oxide content per air-dry matter , %											
SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MgO	MnO	CaO	Na_2O	K_2O	P_2O_5	SO_3	CO_2
2.87	0.02	0.32	0.29	19.17	0.01	31.48	0.05	0.15	0.03	0.30	45.00

Phosphogypsum in the dumps of Almalyk is in the form of calcium sulfate dihydrate ($CaSO_4{\cdot}2H_2O$) with a moisture content of 18-20%. Therefore, before adding it to ammonium nitrate, it was dried in a thermostat at 90°C and then ground in a porcelain mortar. Composition of dry phosphogypsum (wt %): P_2O_{5total}.1,59; P_2O_{5ass}.1.48; P_2O_{5water}.1.12; CaO_{total}.37.47; CaO_{ass}.19.08; CaO_{water}.11.26; SO_{3total} 54.49; SO_{3ass}.27.4; SO_{3water}.16.88. DM and FG were preliminarily ground in a porcelain mortar to a size of 0.25 mm. The experiments were carried out as follows: melted at 175°C in a metal cup by electric heating. DM was added to AS in such an amount that the mass ratio AS : DM in the mixture varied from 100:3 to 100:45. FG was taken in amounts of 3, 5, 7, and 10% of the total mixture weight. The mixture was thoroughly mixed. The melts were kept at a temperature of 170-175°C. The total interaction time of the components was 10 min. The dolomite-gypsum-nitrate melt after the completion of the interaction of the components was poured into a porcelain cup and, as it cooled, was intensively stirred with a glass rod, resulting in granulation. The mass was cooled and then dispersed according to particle size. Particles with dimensions of 2-3 mm were tested for strength according to GOST 21560.2-82. The granular fertilizers obtained in this way were analyzed according to known methods [13]. The caking capacity of fertilizers was determined by the express method [14]. Briquetting conditions: sample compression pressure with a load of 2.8 kg, temperature - 50°C; the length of stay of the cylindrical cassette in the mold is 8 hours. The briquettes were tested for destruction using the IPG-1M instrument. The caking capacity of samples X (in MPa) was calculated by the formula: X = P / S where, P is the breaking force, N (kgf); S is the cross-sectional area of the sample (cm2). The absorbency of the granules in relation to liquid fuel (solar oil) was determined according to the method provided for by TU 6-03-372-74 on a granular porous AU brand "P". This indicator is expressed as the number of grams that can absorb 100g of granules (g/100g).

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IV. EXPERIMENTAL RESULTS

The results are presented in tables 2 and 3.

Table 2.
Chemical composition of magnesium lime-ammonium nitrate obtained on the basis of AS liquid, DM and FG addition.

AS: DM weight ratio	The amount of FG in the mixture, %	Amount of components, %			
		N	SO_3	CaO	MgO
AS liquefaction + "Shursu" mine DM + FG					
100 : 3	3	32,94	1,56	2,0	0,52
100 : 3	5	32,21	2,75	2,75	0,51
100 : 3	7	31,56	3,81	3,47	0,49
100 : 3	10	30,55	5,44	4,55	0,48
100 : 10	3	30,83	1,62	3,89	1,65
100 : 10	5	30,21	2,71	4,56	1,62
100 : 10	7	29,56	3,79	5,26	1,59
100 : 10	10	28,61	5,42	6,31	1,53
100 : 20	3	28,27	1,63	6,21	3,06
100 : 20	5	27,67	2,71	6,84	3,01
100 : 20	7	27,09	3,82	7,49	2,95
100 : 20	10	26,21	5,43	8,45	2,84
100 : 30	3	26,09	1,62	8,15	4,26
100 : 30	5	25,54	2,71	8,76	4,18
100 : 30	7	25,02	3,81	9,36	4,09
100 : 30	10	24,19	5,41	10,27	3,96
100 : 45	3	23,39	1,68	10,58	5,74
100 : 45	5	22,26	2,72	11,14	5,61
100 : 45	7	22,41	3,79	11,69	5,49
100 : 45	10	21,72	5,39	12,49	5,31

It can be seen that the total amount of nitrogen in the studied weight ratio of the products decreased from 32,94 to 21,72%, while the amounts of SO_3, CaO and MgO decreased from 1,56 to 5,39%, 2,0 to 12,49%, respectively. and increased from 0,48 to 5,74%. The sum of nutrient components of these fertilizers (N + SO_3 + CaO + MgO) is in the range of 36,98-45,34%. According to the results presented in Table 2, the strength of lime-ammonia nitrate grains with phosphogypsum addition increased from 4,36 to 13,68 MPa, and viscosity, porosity, and diesel fuel absorption increased from 3,03 to 0,78 kg/cm^2, respectively. 85 to 4,27% and 2,85 to 0,89 gr. has been found to have decreased to.

Table 3.
Strength, viscosity, porosity and diesel oil absorption of OAS granules with FG addition obtained on the basis of AS fluidization, DM and FG.

AS: DM weight ratio	The amount of phosphogypsum in the mixture, %	Grain strength, MPa	Grain viscosity, kg/cm2	Grain porosity, %	Grains absorb diesel oil, gr.
NH4NO3 of granular «t» brand		1,32	5,62	22,0	4,82
AS with granular magnesite		1,58	4,67	9,10	4,33
100 : 3	3	4,36	3,03	7,85	2,85
100 : 3	5	4,52	2,96	7,72	2,77
100 : 3	7	4,81	2,80	7,57	2,68
100 : 3	10	5,03	2,77	7,41	2,59

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100 : 10	3	6,29	2,55	7,09	2,43
100 : 10	5	6,51	2,46	6,95	2,34
100 : 10	7	6,72	2,31	6,78	2,26
100 : 10	10	6,96	2,28	6,62	2,17
100 : 20	3	8,14	2,12	6,31	2,00
100 : 20	5	8,31	2,04	6,16	1,91
100 : 20	7	8,68	1,95	5,99	1,83
100 : 20	10	8,82	1,86	5,83	1,74
100 : 30	3	10,02	1,63	5,53	1,57
100 : 30	5	10,25	1,54	5,37	1,48
100 : 30	7	10,47	1,42	5,21	1,40
100 : 30	10	10,72	1,35	5,06	1,31
100 : 45	3	12,81	1,13	4,74	1,15
100 : 45	5	13,07	1,04	5,58	1,06
100 : 45	7	13,29	0,91	4,43	0,97
100 : 45	10	13,68	0,78	4,27	0,89

For comparison, in granular "pure" brand NH4NO3 and AS grains with magnesite, these indicators are 1,32 and 1,58 MPa, 5,62 and 4,67 kg/cm^2, 22 and 9,10%, and 4,82 and 4, respectively. 33 gr. is Thus, the higher the strength of the granules, the lower their porosity, and the less the granules absorb diesel fuel, and as a result, the explosive properties of ammonium nitrate are reduced. In this respect, dolomite mineral and phosphogypsum showed themselves well

V. CONCLUSION AND FUTURE WORK

In conclusion, it can be said that by adding dolomite mineral and phosphogypsum to ammonium nitrate liquid in all studied proportions, it is possible to obtain granular lime-ammonium nitrate with improved product properties.

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