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Magnesium Containing Lime-Ammonium Nitrate and Rheological Properties of its Melts

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ABSTRACT. The composition of magnesium-containing lime-ammonium nitrate (IAS) was determined based on the melt of ammonium nitrate (AS) and local dolomite flour (DM) (Karnab, Shursu, Navbakhar, Ketmonchi and Dekhkanabad deposits) at mass ratios AC: DM = 100: (3-40). The rheological properties of the magnesium-containing IAS melts were studied at the ratio AC: DM = 100: (3-40)) and temperatures from 165 to 180 °S. It was shown that the density and viscosity of the melt of magnesium-containing IAS significantly increases with increasing amount of DM. The viscosity of the melts is more responsive to temperature changes, and the density varies slightly. The lowest value of density and viscosity is the melt obtained in the case of using DM Ketmonchi field. The rheological properties of the magnesium-containing IAS melts in a wide range of AS: DM ratios and temperatures have a fairly good fluidity, they can be easily granulated by prilling.

KEYWORDS: Ammonium nitrate melt, dolomite flour, composition, granule strength, density and viscosity.

I. INTRODUCTION

The most common and effective nitrogen fertilizer in the world is ammonium nitrate. But she has three very serious flaws. Firstly, it is explosive, secondly, caking during storage, and thirdly, its physiologically acidic nature, which does not allow its use on acidic soils. In order to eliminate these shortcomings of ammonium nitrate, a technology was developed for producing IAS by introducing calcareous materials (limestone, chalk or dolomite) into the melt of ammonium nitrate. Around the world, such nitrate with a nitrogen content of 20-33% is currently produced by 42 companies, of which 31 are located in Europe, where acid soils are most abundant [1, 2]. The share of IAS capacities is estimated at approximately 7% [3]. In recent years, Russian plants: Angarsk Mineral Fertilizer Plant, KuybyshevAzot, OJSC Dorogobuzh, OJSC NevinnomysskyAzot, and Novomoskov AK Azot began to produce IAS with a nitrogen content of 32%.

The use of a stable form of ammonium nitrate for agricultural needs is of great importance from the point of view of safety, which significantly simplifies the procedure for acquiring this type of fertilizer and opens up great opportunities for its export. That is, by reducing the nitrogen content in ammonium nitrate (not more than 28% N) by introducing ~ 26% cheaper Ca, Mg - containing component (dolomite, chalk, limestone, etc.) into it, it is possible to make nitrate economically attractive. In addition, the price of ammonium nitrate with a magnesia additive significantly exceeds the cost of IAS, and a number of duties on its export are still excluded. The duty on IAS is not extended due to its explosion and fire safety.

Uzbekistan also has several large deposits of dolomite mineral: Shursu (Ferghana region), Navbahor (Navoi region), Karnab (Samarkand region), Ketmonchi (Navoi region), Dekhkanabad (Kashkadarya region) and others. Therefore, it became possible to organize the production of magnesium-containing IAS in Uzbekistan. Earlier [4-6], we studied the composition and properties of a magnesium-containing IAS obtained on the basis of melt AC (34,5% N) and DM “Shursu” and “Navbahor” deposits of Uzbekistan. It was shown that for the studied ranges of the ratios AS: DM = 100:(3-35), products with the addition of the Shursuy dolomite contain 32,77-25,49% nitrogen, and with the addition of the Navbahor dolomite they contain 32,52-25,54 nitrogen. The strength and time of complete dissolution of the granules of pure ammonium nitrate are 1,32MPa and 44,6 seconds. The introduction of dolomite into the melt of ammonium nitrate increases both the strength and the time of complete dissolution of the granules. So, if at a ratio of AC: DM = 100:3 (Shursuy dolomite) the strength of the granule is 2,81MPa and the time of complete dissolution of the granule is 57,71 sec, then at a ratio of AC: DM = 100:35, these indicators are as follows: 10,18 MPa and 67,85 sec.

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In the case of using Navbahor Dolomite with a ratio of AS: DM = 100:3, the strength of the fertilizer granule is 3,44MPa, and the time of complete dissolution of the granule is 58,82 sec, with a ratio of AC: DM = 100:35 these indicators are 10,44 MPa and 71, 26 sec. These data indicate that the resulting fertilizers have greater thermal stability than pure ammonium nitrate and, compared with it, they will be much more slowly washed out of the soil.

The objective of this work is to study the composition, strength of granules, and rheological properties of products obtained by the interaction of AS melt with powdery dolomite "Karnab" of Samarkand region, "Ketmonchi" of Navoi region and "Dekhkanabad" of Kashkadarya region.

II. SIGNIFICANCE OF THE SYSTEM

The composition of magnesium-containing lime-ammonium nitrate (IAS) was determined based on the melt of ammonium nitrate (AS) and local dolomite flour.The study of literature survey is presented in section III, methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses the future study and conclusion.

III. METHODOLOGY

In laboratory conditions, we used granular AS (34,5% N, 0,28% MgO) manufactured by Maxam-Chirchik JSC as raw materials. The chemical and dispersed composition of the local dolomite flour are shown in Tables 1 and 2. After that, we conducted experiments to obtain magnesium-containing IAS based on AS melt and finely divided DM.

Table 1
The chemical composition of dolomite flour of various deposits

Place of Birth	The content of components, weight. %									
	CaO	MgO	SiO_2	MnO	Al_2O_3	Na_2O	K_2O	P_2O_5	SO_3	CO_2
Navbahor	28,0	24,60	2,14	0,03	0,38	0,17	0,12	0,02	0,20	44,24
Shursu	31,48	19,17	2,87	0,01	0,32	0,05	0,15	0,03	0,30	45,0
Karnab	30,02	19,63	2,74	0,01	0,39	0,27	0,10	0,15	0,39	45,40
Ketmenchi	30,35	19,56	2,12	0,03	0,36	0,06	0,11	0,16	0,42	45,20
Dehkanabad	30,46	20,41	2,30	0,01	0,31	0,055	0,07	0,08	1,12	45,16

Table 2
The dispersed composition of dolomite flour of various deposits

Size class, mm	The output fraction, weight.%				
	Navbahor	Shursu	Karnab	Ketmenchi	Dehkanabad
0,5	13,67	9,70	18,68	18,75	27,84
- 0,5 + 0,315	10,98	11,03	24,57	23,64	13,62
- 0,315 + 0,25	5,60	4,48	5,08	6,20	4,01
- 0,25 + 0,16	3,12	8,62	16,50	15,87	16,78
- 0,16 + 0,063	11,73	17,31	11,13	11,32	11,43
- 0,063 + 0,05	54,90	48,86	24,04	24,22	26,32
Initial mass	**100**	**100**	**100**	**100**	**100**

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Physico-mechanical characteristics of dolomite flour of various deposits

Physico-mechanical characteristics Properties	Indicators				
	Navbahor	Shursu	Karnab	Ketmenchi	Dehkanabad
Humidity%	1,0	1,5	1,23	1,38	1,12
Free density, g / cm3	1,26	1,23	1,27	1,25	1,24
Density with seal, g / cm3	2,82	2,80	2,788	2,81	2,79
Slope angle, degrees	40º02´	41º10´	38º06	42º14	39º56
Flowability, sec.	18,0	17,76	18,40	19,0	17,92
Hygroscopic point,%	42,10	41,65	39,43	42,0	42,89
Moisture content,%	9,22	8,04	7,50	9,06	8,53
pH of a 10% suspension	9,07	8,79	8,67	8,83	8,78

To obtain samples of magnesium-containing IAS, the experiments were carried out as follows. First, dolomite flour was introduced into the AC melt at 175 °S at mass ratios AC: DM from 100: 3,0 to 100: 40. Next, the nitrate-carbonate melt was kept at 175 °S for 3-5 minutes. Then it was poured into a laboratory granulator, which is a metal glass with a perforated bottom, the diameter of the holes in which was 1,2 mm. A pump was created in the upper part of the glass and the melt was sprayed from a height of 35 m onto a plastic film lying on the ground. The resulting granules were scattered by particle size. Particles 2-3 mm in size were tested for strength according to GOST 21560.2-82. After that, the products were crushed and analyzed by known methods [7]. The results are shown in tables 3 and 4.

IV. EXPERIMENTAL RESULTS

From table 3 it is seen that for the studied ranges of the ratios AS: DM = 100: (3-40), products with the addition of Karnab dolomite contain 33,44-23,03% nitrogen, with the addition of Ketmonchin dolomite they contain 33,28-22,96 % nitrogen, and with the addition of Dekhkanabad dolomite, they contain 33,34-23,10% nitrogen. The strength of the pellets of pure AS is 1,60MPa. The strength of the granules of magnesium-containing IAS obtained at the studied ratios AS: DM is in the range of 3,02-14,07 MPa. The high strength of the granules of the magnesium-containing IAS indicates its thermal stability.

Table 3
The strength of the granules of samples of magnesium-containing IAS

№	The mass ratio of the starting components	Pellet strength		
		kg/granule	kgf/sm^2	MPa
1	Granular NH_4NO_3 grade “h”	0,67	13,50	1,32
2	Speakers with magnesia additive (0,28% MgO)	0,80	16,12	1,58
Mass ratio of AS: DM of the Navbahor deposit				
3	100 : 3	1,74	35,08	3,44
5	100 : 10	2,46	49,59	4,86
6	100 : 15	2,67	53,83	5,28
8	100 : 25	4,04	81,44	7,98
10	100 : 35	5,28	106,44	10,44
11	100 : 45	6,59	132,85	13,02
Mass ratio AC: DM of the Shursu deposit				
12	100 : 3	1,42	28,63	2,81
14	100 : 10	2,24	45,08	4,42
15	100 : 15	2,80	56,45	5,53
17	100 : 25	3,92	79,03	7,75
19	100 : 35	5,15	103,82	10,18
20	100 : 45	6,46	130,23	12,77

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Mass ratio AC: DM of the Karnab deposit				
21	100 : 3	1,67	33,67	3,30
23	100 : 10	2,80	56,45	5,53
24	100 : 15	2,97	59,88	5,87
26	100 : 25	3,45	69,55	6,82
28	100 : 35	5,20	104,83	10,28
29	100 : 45	6,53	131,64	12,91
Mass ratio of AS: DM of the Ketmonchi deposit				
30	100 : 3	1,53	30,84	3,02
32	100 : 10	2,56	51,61	5,06
33	100 : 15	2,71	54,63	5,36
35	100 : 25	3,22	64,92	6,32
37	100 : 35	5,0	100,8	9,88
38	100 : 45	6,39	128,82	12,63
Mass ratio AC: DM of the Dekhkanabad field				
39	100 : 3	2,09	42,13	4,13
41	100 : 10	2,67	53,83	5,28
42	100 : 15	2,94	59,27	5,81
44	100 : 25	3,61	72,78	7,14
47	100 : 45	6,55	132,04	12,95

Table 4
Rheological properties of IAS melts based on melt AC and DM of various deposits

Mass ratio AC: DM	**Density (g/cm^3), at a temperature, °S**				**Viscosity (sP) at a temperature, °S**			
	165	170	175	180	165	170	175	180
AC	-	1,450	1,448	1,446	-	5,71	5,34	5,02
Ammonium nitrate melt + dolomite of the Navbahor deposit								
100 : 3	1,591	1,578	1,566	1,554	6,12	5,83	5,61	5,48
100 : 5	1,674	1,653	1,639	1,618	6,49	6,17	6,06	5,92
100 : 10	1,682	1,660	1,645	1,627	6,58	6,43	6,26	6,04
100 : 15	1,690	1,671	1,653	1,645	7,10	6,88	6,63	6,49
100 : 20	1,713	1,694	1,672	1,663	7,84	7,52	7,31	6,97
100 : 25	1,736	1,716	1,707	1,686	9,18	9,06	8,65	8,32
100 : 35	1,768	1,741	1,735	1,722	10,43	9,87	9,64	9,15
Ammonium nitrate melt + dolomite from the Shursu deposit								
100 : 3	1,587	1,567	1,560	1,550	5,92	5,74	5,52	5,32
100 : 5	1,600	1,590	1,582	1,572	6,32	6,08	5,90	5,67
100 : 10	1,608	1,600	1,595	1,587	6,50	6,34	6,06	5,83
100 : 15	1,616	1,610	1,602	1,592	6,91	6,68	6,46	6,29
100 : 20	1,631	1,626	1,620	1,613	7,73	7,15	6,93	6,74
100 : 25	1,652	1,647	1,637	1,631	8,61	8,96	8,18	7,93
100 : 35	1,689	1,681	1,675	1,669	10,06	9,70	9,34	8,71
Ammonium nitrate melt + dolomite from the Karnab deposit								

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100 : 3	1,587	1,567	1,560	1,550	5,92	5,84	5,72	5,62
100 : 5	1,600	1,590	1,582	1,572	6,32	6,28	6,17	5,87
100 : 10	1,608	1,600	1,595	1,587	6,57	6,46	6,36	6,15
100 : 15	1,616	1,610	1,602	1,592	6,73	6,69	6,46	6,29
100 : 20	1,623	1,618	1,612	1,605	7,23	6,87	6,64	6,53
100 : 25	1,631	1,626	1,620	1,613	7,73	7,15	6,93	6,74
100 : 35	1,652	1,647	1,637	1,631	8,61	8,46	8,18	7,93
Ammonium nitrate melt + dolomite from the Ketmonchi deposit								
100 : 3	1,485	1,476	1,472	1,461	5,73	5,68	5,43	5,52
100 : 5	1,511	1,509	1,487	1,475	6,15	6,08	5,87	5,67
100 : 10	1,534	1,600	1,595	1,587	6,23	6,34	6,20	5,83
100 : 15	1,603	1,610	1,602	1,592	6,38	6,18	6,08	5,92
100 : 20	1,632	1,618	1,612	1,605	6,43	6,31	6,27	6,23
100 : 25	1,648	1,626	1,620	1,613	6,68	6,25	6,16	6,04
100 : 35	1,669	1,657	1,647	1,629	7,81	7,76	7,68	7,53
Ammonium nitrate melt + dolomite from Dekhkanabad deposit								
100 : 3	1,598	1,586	1,580	1,571	6,14	6,11	5,97	5,82
100 : 5	1,602	1,598	1,587	1,480	6,25	6,18	6,08	6,17
100 : 10	1,614	1,608	1,595	1,589	6,40	6,34	6,26	6,31
100 : 15	1,621	1,616	1,608	1,596	6,64	6,56	6,48	6,52
100 : 20	1,632	1,628	1,621	1,615	7,11	6,87	6,64	6,53
100 : 25	1,648	1,636	1,627	1,623	7,43	7,15	6,93	6,87
100 : 35	1,667	1,657	1,647	1,631	8,21	8,96	8,18	8,08

As can be seen from table 4, the density and viscosity of the saltpeter melt increase significantly with increasing amount of added additives. An increase in the proportion of Karnabs dolomite from 3 to 50 leads to an increase in the melt density at 165 °S from 1,587 to 1,692 g/sm^3 and viscosity from 5,92 to 10,12 cps. An increase in the fraction of Dekhkanabad dolomite from 3 to 50 leads to an increase in the melt density at the same temperature from 1,598 to 1,683 g/sm^3 and viscosity from 6,14 to 10,20 cPs. With increasing temperature of the melt, its density and viscosity decrease.

The following fact should be noted here. Pure speakers at 165 °S do not melt and, of course, do not flow. And dolomite additives lead to a decrease in its melting point. A mixture of AS with dolomite at AC: DM ratios of 100:3 to 100:50 begins to melt already at 165 °S and although the melt has a high viscosity, it flows easily

V. CONCLUSION AND FUTURE WORK

Based on the results of studying the rheological properties of magnesium-containing IAS melts in a wide range of weight ratios of AS: DM and temperatures, it can be concluded that the melts obtained have fairly good fluidity, so they can be granulated without any special technological difficulties in a granulation tower.

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