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Research of Process of Conversion Astrakhanite Potassium Chloride

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ABSTRACT. On the basis of the obtained data of studying of process of conversion of the astrakhanit chloride of potassium set the following key process parameters of production of sulfate of potassium: mass ratio: potassium chloride: astrakhanit =1:2.09; H_2O: Σ salt =1:1.47; Ж: Т =9.14:1, temperature of conversion 75^0C; duration of conversion is 60-65 minutes; temperature of hot filtration 75^0C, temperature of the first and second stage of boil-off 90^0C at 25-30 minutes, filtration temperature with rainfall of chlorides of potassium and sodium 25^0C.

KEYWORDS:chart, component, liquid and firm phase, balance, potassium sulfate, potassium chloride, conversion, filtation, analysis.

I. INTRODUCTION

The most common ions in natural waters, which determine their properties, are Na^+, K^+, Ca^{2+}, Mg^{2+}, $C1^-$, SO_4^{2-}, HCO_3^-, CO_3^{2-}, Fe^{2+}, Fe^{3+}, Mn^{2+} F^-, Br^-, I^- are found in smaller quantities, B_2O_3, HPO_4^{2-}, SO_3^{2-}, HS^-, $HSiO^{3-}$. They do not have a significant impact on the properties of the brine, but in some cases determine its technological qualities. The chemical composition of natural waters and the total salt content in them, called salinity, are varied. The compositions of many natural waters are applied on the combined salt projection of three- and four-component systems: sodium chloride — magnesium sulfate — water; magnesium chloride - calcium chloride - sodium chloride - water and chloride-, sulfate-, sodium bicarbonate and water. As can be seen, the composition of natural waters with some limitations can be characterized by a system in which there will be at least eight components Ca^{2+}, Mg^{2+}, Na^+, K^+//CO_3^{2-}, $2HCO_3^{2-}$, Cl^-, SO_4^{2-} H_2O. The visual image of such complex systems requires many simplifications and practically loses its meaning. Consideration and study of the processes occurring in them is extremely difficult, therefore, naturally, there is a need for their rational classification [1].

II. SIGNIFICANCE OF THE SYSTEM

On the basis of the obtained data of studying of process of conversion of the astrakhanit chloride of potassium set the following key process parameters of production of sulfate of potassium. 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. LITERATURE SURVEY

In halurgic practice, an important process takes place in the $2Na^+$, $2K^+$, Mg^{2+} ‖ $SO_4^{2-}2C1^-$, H_2O system, approximately corresponding to the composition of seawater at 25°C. This system adequately describes the processes of concentration of sea water, both in laboratory and in natural conditions. Due to the fact that natural evaporation occurs in areas with an arid climate (desert climate), the average temperatures of the evaporation season are 25–35°C [2, 3].

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IV. METHODOLOGY

Potassium chlorides and sulfates are the equilibrium phase of the five-component “marine” system $2Na^+$, $2K^+$, Mg^{2+} || SO_4^{2-}2C1$^-$ H^{2}O at 25ºC, and their participation in the formation of its geometric patterns is of definite scientific and technical interest.

Four-component systems $2K^{+,}$ Mg^{2+} || SO_4^{2-}2C1$^-$, H_2O are well studied by the solubility method [4-7], and five-component systems by the translation method [8-11].

When studying the conversion process, a round bottom flask with a capacity of 500 sm^3, equipped with a stirrer, was used to load the calculated number of components. The flask was placed in a thermostat with a given temperature and stirred vigorously. After the required period of time, the liquid phase was separated from the precipitate and the corresponding chemical and physicochemical analysis was performed.

V. EXPERIMENTAL RESULTS

In the $2Na^+$, $2K^+$, Mg^{2+} || SO_4^{2-}2C1$^-$, H_2O system solubility diagram, the crystallization of glaserite and arcanite occupy a significant part – 34,75 and 27,39%, respectively, therefore, to recommend processing salt deposits of the Aral region potassium chloride according to the diagram along the line of astrakhanite-potassium chloride.

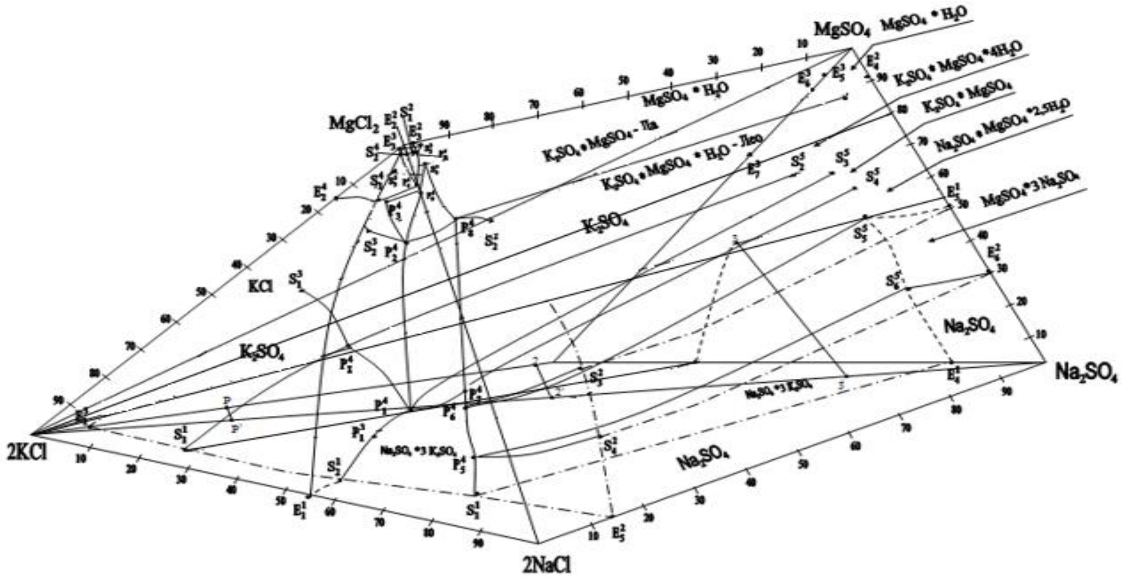

Figure 1. The volumetric image of the system $2Na^+$, $2K^+$, Mg^{2+} // SO_4^{2-}, 2Cl$^-$ —H_2O at 75 °C

Certain difficulties are created for the calculation of the conversion process with the use of a volume diagram, in connection with which the section of the diagram on the Na_2SO_4 – $MgSO_4$ – KCl plane is obtained (Fig. 2). This allows you to calculate the mass ratio of potassium chloride (m_{KCl}) and sulfate salts, consisting of sulfates of sodium and magnesium. From figure 2 it can be seen that potassium sulphate can be obtained in two ways: direct production of potassium sulphate or through a double compound glaserite or leonite.

In the process of direct synthesis of K_2SO_4, the M_{KCl}:M_{SS} ratio must be maintained at least 6,33; 0,95; 0,90, respectively, when using sodium sulfate, anhydrous astrakhanite and magnesium sulfate.

It follows that with an increase in the magnesium content in the feedstock, the M_{KCl}/M_{SS} ratio decreases. The second method is carried out at a ratio of M_{KCl}/M_{SS} more than 6,33; 0,95; 0,90, respectively, when using sodium sulfate, anhydrous astrakhanite and magnesium sulfate.

It should be noted that when $Na_2SO_4/MgSO_4$ = 1.0: 0-1.0: (1.0-2.5), glaserite is first formed, which is processed to potassium sulfate and sodium chloride or (magnesium chloride).

At 1.0: (1,0-2,5): 1.0, Leonit is first formed, which is processed to potassium sulfate, magnesium chloride and sodium.

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The interval of variation of parameters is optimized by carrying out balance experiments. For example, when carrying out the conversion process using Astrakhanite on pure sodium and magnesium sulphates, sufficient scientific data are available in the literature.When using the original sulfate from salt usingAstrakhanite, the ratio M_{KCl}/M_{SS} in the K_2SO_4 formation region is 2,29 and 0,87.

Figurative points a, and a2 in the diagram (Fig. 3) show the progress of the process according to the following reaction: $Na_2SO_4 \cdot MgSO_4 \cdot 4H_2O + 2KCl \rightarrow 2K_2SO_4 + MgCl_2 + 2NaCl$ with the stoichiometric ratio $M_{KC}l/M_{Act}$ = 0.89. The obtained experimental data are presented in table1.

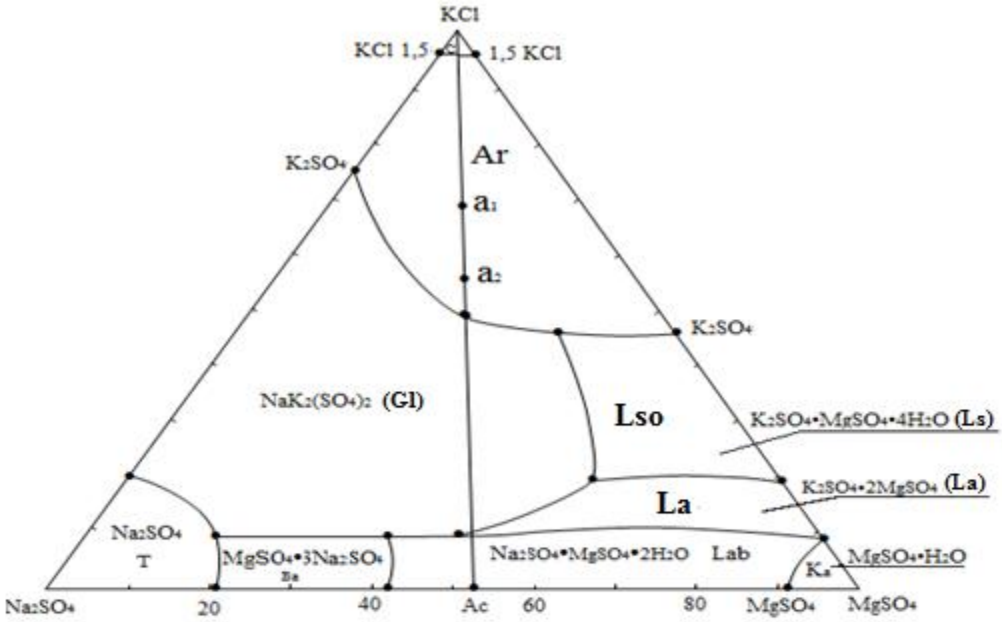

Fig.2. View of the section of the $Na_2SO_4 – MgSO_4 – KCl$ plane obtained from the Na^+, K^+, $1/2Mg^{2+}$ // 1 / $2SO_4^{2-}$, Cl^- –H_2O diagram at 750 °C

With this in mind, in order to issue practical recommendations on the processing of salt deposits of the Aral region, the conversion process was investigated depending on the ratio of G: T for 60 minutes at 750 °C.

Table 1 shows the effect of the M_{KCl}/M_{AST} ratio, $M_{H2O}/M\Sigma_{salt}$ and magnesium chloride content on the chemical composition of the obtained product and the liquid phase.

After the filtration process at 75 °C, the reaction phase and the filtrate were cooled to room temperature (25 °C). In the case of precipitation of crystals again filtered to separate the precipitated crystals. The obtained precipitates of hot and cold filtration and the mother liquor were analyzed for the content of Na^+, K^+, Mg^{2+}, Cl^- and sulfate ions.

As the data in Table 1 show, at M_{KCl}/M_{Act} = 2.29, the $M_{H2O}/M\Sigma$ ratio decreases, the composition of both solid phases remains almost unchanged; during hot filtration, potassium sulfate is formed with a certain amount of Na^+, $Cl^−$ ions and traces of magnesium. And during cold filtration, potassium chloride precipitates. When the ratio M_{KCl}/M_{Act} is 0.87, despite the fact that the ratio $M_{H2O}/M\Sigma_{salt}$ is lower than in the first variant, hot filtration also forms potassium sulfate with a high content of sodium ions, and during cold filtration the formation of a solid phase is not observed.

When using 10 and 20% solutions of magnesium chloride as a circulating solution, the amount of precipitated precipitates increases and, at the same time, the content of magnesium and chlorine in both sediments increases.From table 2 it can be seen that with a change in the ratio $M_{H2O}/M\Sigma_{salt}$, W:$T\Sigma_{salt}$ in the reaction suspension at M_{KCl}/M_{Act} = 2.29 and 0.87 varies in the intervals of 3.26-9.14 and 3.04-5.78, respectively . With the use of 10 and 20% solutions, this indicator is 9.21 and 3.43, respectively. It should be noted that with a decrease in the $M_{H2O}/M\Sigma_{salt}$ ratio, the filtration rate increases, and the humidity decreases and fluctuates in the intervals of 1795.8 ÷ 6823.2 kg / m^2, h, 10.31 - 13.54% with M_{KCl}/M_{AST} = 2.29 and 2304.2-3418.3 kg / m^2, h, 11.18-12.77%.It should be noted that with an increase in the magnesium chloride content in the working solution, the filtration rate increases and the humidity of the precipitate decreases, which is explained by a decrease in the viscosity of the solutions.

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Table 1
The chemical composition of the solid and liquid phase after the conversion of astrakhanite with potassium chloride

№	M_{KCl}/M_{Acr}	$M_{H2O}/M_{\Sigma salt}$	Hot filtering					Cold filtration					The composition of the liquid phase,%					The density of the liquid phase
			The composition of the solid phase%					The composition of the solid phase,%										
			Na^{+}	K^{+}	Mg^{+2}	Cl^{-}	SO_4^{-2}	Na^{+}	K^{+}	Mg^{+2}	Cl^{-}	SO_4^{-2}	Na^{+}	K^{+}	Mg^{+2}	Cl^{-}	SO_4^{-2}	
1	2,29	1,47	4,7	42,6	0,29	2,7	52,4	0,6	46,2	0,29	42,0	2,0	2,05	9,2	1,11	14,89	1,51	1,200
2	2,29	1,17	4,6	41,4	0,29	3,1	51,0	0,4	46,0	0,29	41,8	0,86	2,24	9,21	1,21	16,07	1,69	1,206
3	2,29	0,87	4,0	39,0	0,40	3,0	48,0	0,7	46,0	0,30	41,8	0,5	2,99	8,17	1,62	21,43	2,03	1,213
4	0,87	1,29	7,0	43,8	0,40	1,9	53,9	-	-	-	-	-	2,61	17,94	1,42	20,56	4,05	1,205
5	0,87	1,04	7,0	41,7	0,60	2,0	51,4	-	-	-	-	-	2,96	19,67	1,60	22,31	3,55	1,224
6	0,87	0,79	7,1	42,6	0,50	2,5	52,5	-	-	-	-	-	3,35	21,63	1,82	24,25	3,18	1,244
	Using a 10% solution of magnesium chloride																	
7	2,29	1,47	2,86	42,3	0,61	2,7	52,0	0,55	45,2	0,39	41,0	1,03	2,86	9,49	2,89	19,19	5,04	1,239
	Using a 20% solution of magnesium chloride																	
8	2,29	1,47	0,67	42,1	0,67	2,8	51,8	0,94	46,2	0,34	42,0	2,71	2,60	4,86	5,38	28,06	4,16	1,263

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Table 2

The effect of the amount of working solution on the technological parameters of the process of conversion of potassium chloride by Astrakhanite at 75 ° C

№	Ratio		Hot Filtration					Cold Filtration				
	$M_{KCl}/M_{Aст}$	$M_{H2O}/M_{\Sigma\ salt}$	Ж:T	Filtration rate, kg/m^2*h		Humidity of the solid phase,%	Output by K_2O, %	W:T	Filtration rate, kg/m^2*h		Humidity of the solid phase,%	Output by K_2O, %
				solidphase	liquidphase				solid phase	liquid phase		
	Without the use of magnesium chloride											
1.	2,29	1,47	9,14:1	17,95,8	14913,4	13,57	31,41	22,12:1	2196,2	38377,5	20,10	12,14
2.	2,29	1,17	4,75:1	4045,3	17327,7	10,90	48,64	17,37:1	2591,2	33459,2	24,27	12,22
3.	2,29	0,87	3,26:1	6823,2	15119,4	10,35	67,13	16,62:1	2735,8	35830,3	20,0	9,08
4.	0,87	1,29	5,78:1	2304,2	12715,4	12,77	28,54	-	-	-	-	-
5.	0,87	1,04	3,90:1	3005,7	14664,3	12,03	30,32	-	-	-	-	-
6.	0,87	0,79	3,04:1	3148,3	9193,3	11,18	32,35	-	-	-	-	-
	Using a 10% solution of magnesium chloride											
7.	2,29	1,47	9,21:1	1808,4	13793,3	13,30	35,56	15,74:1	1989,2	30905,5	21,6	15,19
	Using a 20% solution of magnesium chloride											
8.	2,29	1,47	3,43:1	1901,8	5439,6	12,9	68,70	13,82:1	2301,8	24698,2	20,9	15,11

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VI. CONCLUSION AND FUTURE WORK

Thus, the constructed volumetric image of the six-component system $2Na^{+}$, $2K^{+}$, Mg^{2+} // SO_4^{2-}, $2Cl^{-}$ H_2O allows you to easily determine the boundaries of the contacting areas of crystallization of salts and calculate their volume fractions, which allows orientation of technological calculations of salt deposits of marine type and their education. With the study of the conversion process of astrakhanite with potassium chloride, the optimal technological parameters of the process for the production of potassium sulfate were established.

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