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Obtaining Caustic Soda and Burkeite by Caustification of Mixture of Corbonate and Sodium Sulphate

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The optimal technological parameters for the production of caustic soda from sodium carbonate and sulfate and calcium hydroxide have been established. The influence of the concentration of lime milk on the rate of filtration by sediment and filtrate has been studied.

Purpose of the Work: The purpose of this work is to determine the physicochemical basis for the production of sodium hydroxide and burkeite by causticization of sodium carbonate and sulfate.

Scientific Novelty: In comparison with the known works, a theoretical profoanalytical analysis of the one-cation of four-component system $Na^{+}, OH^{-}, CO_3^{2-}, SO_4^{2-}$and its constituents was carried out for the first time, and also determined the optimal technological parameters of causticization of solutions for local carbonates and sodium sulfates.

Features of the Work:

- the influence of the main technological parameters on the processes of causticization, filtration, evaporation;
- research of intermediate and finished products by modern physicochemical methods;
- study of the rheological properties of the solution depending on the temperature and concentration of the resulting solutions.

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Keywords: Soda ash; mirabilite; lime milk; sodium hydroxide; temperature; ratio; residue; filtration; density; viscosity; sediment; reaction; crystal.

1. INTRODUCTION

It is known [1,2] that when caustic soda is obtained by causticization, to prevent the formation of personite $Na_2CO_3 \cdot CaCO_3 \cdot 2H_2O$, weak liquors are obtained containing about 130g/l$NaOH$,30 g/lNa_2CO_3 and 11,3 g/lNa_2SO_4.

In the further process of evaporation of the causticizing solution, it is important not only to maximally isolate impurities into the solid phase, but also to obtain large rapidly precipitating crystals of Na_2CO_3 , Na_2SO_4 and $Na_2CO_3 \cdot 2Na_2SO_4$,for which it is necessary to maintain the ratio
$Na_2SO_4 : Na_2CO_3$at least 0.5 [3]. Therefore, before feeding to the evaporation to achieve this ratio in the clarified weak liquor, it is customary to add a lack of sodium sulfate [4].

2. METHODOLOGY

Thesystems $Na_2CO_3 - Na_2SO_4 - H_2O$;$Na_2CO_3 - NaOH - H_2O$;$Na_2SO_4 - NaOH - H_2O$ have been studied by the isothermal solubility method at temperatures 25, 50, 75 and 100ºC. The crystallization fields of $Na_2SO_4 \cdot 2H_2O$, Na_2SO_4, $Na_2CO_3 \cdot 7H_2O, Na_2CO_3 \cdot H_2O$ and double salt $2Na_2SO_4 \cdot Na_2CO_3$are differentiated. Microscopic and qualitative X-ray phase analysis of the obtained products was carried out. After equilibrium was established, samples of the liquid and solid phases were taken for analysis and determination of the location of the figurative point of the system. The samples were analyzed for the content of sulfate, carbon oxides, sodium and calcium.

The initial components, evaporated liquid phase and the dried sediment have been analyzed for the content of $Na^+, OH^-, CO_3^{2-}, SO_4^{2-}$ ions according to well-known methods [4-5].

We have previously shown [3-5] that when causticizing soda ash in the presence of natural mirabilite at various ratios of $Na_2CO_3 : Na_2SO_4$,weak solutions are formed containing $NaOH$, Na_2CO_3, Na_2SO_4.

To determine the method of processing this solution, a theoretical graphic-analytical analysis of one-cation four-component system $Na^+ // OH^-, 1/2CO_3^{2-}, 1/2SO_4^{2-} - H_2O$ and its components $Na^+ // OH^-, 1/2CO_3^{2-} - H_2O$; $Na^+ // OH^-, 1/2SO_4^{2-} - H_2O$; $Na^+ // SO_4^{2-} - H_2O$ have been carried out. (Fig. 1, Table 1) [6,7]. In this case, two options for processing this solution have been established:

-when the ratio $Na_2CO_3 : Na_2SO_4 = 1:0 - 0.5:0.5$ with obtaining in the stage of causticization a weak solution of the composition (wt.%): $NaOH - 9.5$; $Na_2SO_4 - 6.10$; $Na_2CO_3 - 6.0$. After evaporation of such a solution, burkeite and caustic soda with a concentration of at least 30% can be obtained.

-when the ratio $Na_2CO_3 : Na_2SO_4 = 0{,}2:0{,}8 - 0:1$ to obtain at the stage of causticization a weak solution of the composition (wt.%): $Na_2SO_4 - 8{,}2$; $Na_2CO_3 - 6{,}0$. After evaporation, purified sodium sulfate and a significant amount of concentrated $NaOH$ can be obtained. However, this process is energy-intensive and low-tech, and therefore it is advisable to carry out the vaporization with the addition of the calculated amount of soda ash. When the degree of evaporation is not more than 60%, burkeite precipitates, after the separation of which the mother solution returns to the beginning of the process.

3. RESEARCH RESULTS

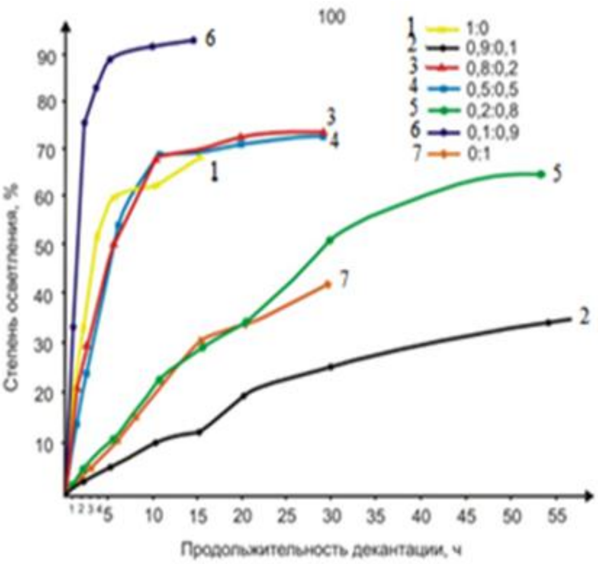
Studies [4,7,8] have shown that during causticization of soda ash and sodium sulfate, depending on the ratio of the initial components and the process temperature, solutions of $NaOH$, Na_2CO_3 , Na_2SO_4 are formed, practically free of calcium and magnesium ions.

The results of experiments and analysis of the four-component system $NaOH - Na_2CO_3 - Na_2SO_4 - H_2O$ showed that the evaporation of the resulting solution also forms $Na_2CO_3 \cdot 2Na_2SO_4$- burkeite.
Therefore, from soda ash and natural low-quality mirabilite, it is possible to simultaneously obtain a solution of sodium hydroxide and burkeite. Therefore, in the future, the process of causticization of a solution of calcined soda with lime milk in the presence of mirabilite has been studied. In the experiments, the mass ratio of $Na_2CO_3 : Na_2SO_4$, the norm, the concentration of lime milk, the rate of clarification and filtration of

the suspension have been determined. The liquid and solid phases were analyzed for the content of $Na^{+}, Ca^{2+}, Mg^{2+}, OH^{-}, CO_3^{2-}, SO_4^{2-}$ ions by well-known methods [9-10].

The content of $OH^{-}, CO_3^{2-}, SO_4^{2-}$ ions, depending on the stoichiometric norm of $Ca(OH)_2$ and the ratio of $Na_2CO_3 \cdot 2Na_2SO_4$,, ranges from 0.33-3.49; 0-10.7 and 0.11-2.62% respectively. The kinetics of the process (Fig. 1) of settling is characterized by clarification for 5 hours at a ratio of $Na_2CO_3 : Na_2SO_4 = 1:0$. In this case, the degree of clarification reaches only 60% by the formation of a turbid liquid phase, and the thickened part is not clearly separated. With an increase in the proportion of sodium sulfate to the ratio $Na_2CO_3 \cdot 2Na_2SO_4 = 0.5:0.5$, the transparency of the liquid phase increases with the proportion of the condensed part of 40-45%. A further increase in this ratio leads to a reduced proportion of the thickened part to 5-10% within 5 hours.

When causticizing, the ratio of Liquid:Solid (L:S) in the system fluctuates in the range (9-1.39): 1, and the filtration rate does not exceed 40-120 kg / m2h. One of the reasons for the low filtration rate is the high (L:S)value and the content of particles with different diameters, from which small particles are precipitated at much lower rates.



The L:S ratio of the suspension has a great influence on the filtration rate. In the experiments, the suspension ratio L:S and the temperature varied within 2-13: 1 and 30-90°C, respectively.

The filtration rate in the causticization process without using a circulating solution ranges from 119-411 kg/m^2·h with a ratio of $Na_2CO_3 : Na_2SO_4 = 1:0$in the intervals L:S - (2-13): 1.

With an increase in the content of Na_2SO_4, in the system, the sediment gradually loses its friability (Fig. 2, a and b) and turns into an adhesive mass (c, d), which significantly reduces the rate of the filtration process. The average crystal size of the sediment is 3.63 microns.

Fig. 1. Kinetics of suspension clarification. Norm of $Ca(OH)_2$- 100%

(a) **(b)**

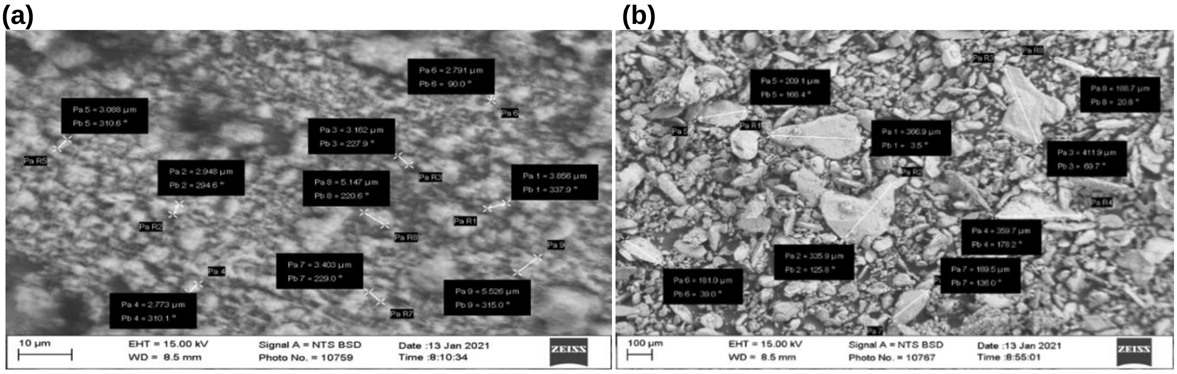


Fig. 2. Microscopic images of samples: a) sludge; b) sediment during evaporation

Table 1. Influence of technological parameters on the filtration rate of the pulp

Samplenumbers	Ratio Na_2CO_3: Na_2SO_4	NaOH content in the circulating solution, wt%	Stages	Filtration rate, kg / m2 · h		Sediment moisture %	L:Sratio in suspension
				Inthesolidphase	Intheiquidphase		
1	1:0	3	filtration	144.01	901.3	26.5	1:8
			flushing	1996.3	5912.1	17.6	
2		7	filtration	162.10	796.2	16.4	1:8
			flushing	599.1	1802.1	16.7	
3		11	filtration	153.3	425.5	16.5	1:6
			flushing	1348.2	3162.1	21.3	
4	1:2	3	filtration	318.4	1823.2	8.13	1:8
			flushing	608.1	1827.2	15.4	
5		7	filtration	248.3	1047.1	28.3	1:7
			flushing	1383.2	3287.2	32.2	
6		11	filtration	215.4	845.3	28.3	1:7
			flushing	474.5	1690.2	32.4	
7	1:5	3	filtration	127.4	575.4	28.4	1:8
			flushing	326.4	1191.1	36.2	
8		7	filtration	110.5	449.5	32.3	1:10
			flushing	209.5	747.4	32.5	
9		11	filtration	103.8	424.3	48.3	1:8
			flushing	262.3	846.3	48.2	

With the ratio $Na_2CO_3 : Na_2SO_4 = 0.8 : 0.2$ when using a circulating solution in the causticization process, the filtration rate is 25 - 82 kg / m2h higher than with the ratio $Na_2CO_3 : Na_2SO_4 = 1 : 0$. However, at L:S = 13: 1 it is 19kg/m^{2}h lower. It should be noted that with the ratio $Na_2CO_3 \cdot 2Na_2SO_4 = 0.5 : 0.5$, the filtration rate is almost 2-4 times lower than with the ratios 1: 0; 0.8:0.2 in the interval L:S = 2-13:1.

In order to increase the $NaOH$ content to 8.2% in a weak lye, the causticization process has been carried out with a circulating solution with a concentration of 3.7 and 11% $NaOH$. With a ratio of $Na_2CO_3 : Na_2SO_4 = 1 : 0$ and 0.8:0.2 and a concentration of a circulating solution of 3 and 7% NaOH within 20 hours, the degree of clarification reaches 80, 60, 70 and 30%, respectively, and when the ratio ratio $Na_2CO_3 \cdot Na_2SO_4 = 0.5 : 0.5$ does not exceed 30 and 20% (Fig. 3).

At a later date, we studied the process of evaporation of weak solutions formed during the causticization of sulfate-carbonate-sodium solutions with the ratio $Na_2CO_3 : Na_2SO_4 = 1.0; 0.8 : 0.2; 0.5 : 0.5$. To carry out the stripping process, weak solutions were prepared with the indicated ratios of the components obtained by causticizing soda ash at a temperature of 95^{o}C, a rate of 18% lime milk 100%, a process duration of 2 hours and atmospheric pressure. After reaching the given degree of evaporation, the suspension was filtered to separate the precipitated crystals.

The content of ions in a weak solution (wt%): $Na^+ - 6.11; 4.17; Ca^{2+} - 0.04; 0.02; 1.02; OH^- - 2.71; 1.91; 1.13; CO_3^{2-} - 2.12; 0.58; 0.59$; respectively, with the ratio $Na_2CO_3 : Na_2SO_4 = 1.0; 0.8 : 0.2; 0.5 : 0.5$.

Experimental data (Table 4) showed that with a decrease in the ratio $Na_2CO_3 : Na_2SO_4$ from 1:0 to 0.5:0.5 and an increase in the degree of evaporation from 60 to 80%, a solid phase is formed, the amount of which at ratios $Na_2CO_3 : Na_2SO_4 = 1.0; 0.8 : 0.2; 0.5 : 0.5$ increases from 1.97-4.68 to 3.66-5.78 and 8.05-12.67 kg, respectively. When the ratio $Na_2CO_3 : Na_2SO_4 = 0.5 : 0.5$, the solid phase is also formed at a lower degree of evaporation - 40%. The maximum amount of solid phase 8.05-12.67 kg is formed when the ratio of the initial components is 0.5:0.5 and the degree of evaporation is 60-80%.

To determine the mineralogical composition of sediments formed during causticization, the X-ray phase research method has been used [10, 11].

As the X-ray diffraction patterns of sediments show (Fig. 4 and Table 5), the main constituent mineral is $CaCO_3$, the amount of which is 35-80%. Its content increases with a growth in the amount of Na_2SO_4 in the initial soda-sulfate solution. The content of $CaSO_4 \cdot 2H_2O$ practically does not depend on the ratio $Na_2CO_3 : Na_2SO_4$. With the ratio $Na_2CO_3 : Na_2SO_4 = 0.5 : 0.5$, the burkeite content is more than 27%.

With increase in the $NaOH$ content in the circulating solution, the filtration rate decreases at all selected ratios of $Na_2CO_3 : Na_2SO_4$ and fluctuates in the range 103.8-318.4 kg / m2h, and the highest rate is appeared with the ratio $Na_2CO_3 : Na_2SO_4 = 0.8 : 0.2$. With these ratios in the studied intervals of variation of the $NaOH$ concentration in the circulating solution, the filtration rate ranges within 215-318 kg / m2 h, the moisture content of the sediment is 8-28%,L:S in the suspension is 7-8:1. The content of ions $OH^-, CO_3^{2-}, SO_4^{2-}$ is (wt.%); 3.30-6.70, 2.1-2.4 and 0.11 - 0.64, respectively (Table 1-3).

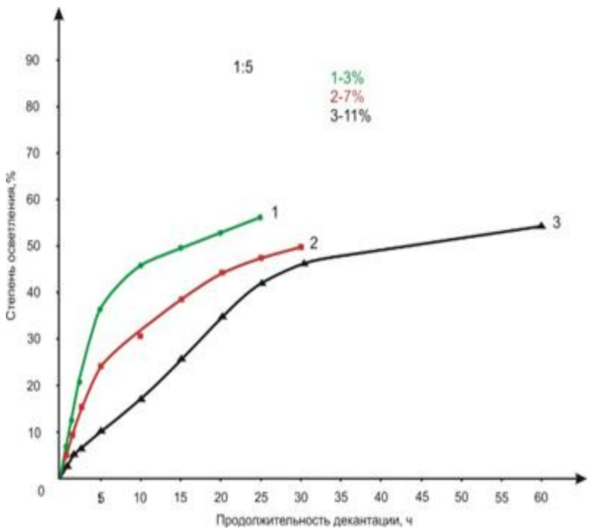


Fig. 3. Kinetics of suspension clarification. $Na_2CO_3 : Na_2SO_4$ ratio: 0.5:0.5

Table 2. Influence of technological parameters on the ionic composition of the causticization suspension filtrate

Sample numbers correspond to the numbers in Table 1.	Ioncontent, wt%				
	Na^+	Ca^+	OH^-	SO_4^{2-}	CO_3^{2-}
1	7.76	0.019	4.05	0.81	2.50
2	9.61	0.04	5.71	0.71	2.01
3	11.5	0.04	7.41	0.60	1.60
4	6.07	0.03	3.30	2.4	0.64
5	8.47	0.04	5.11	2.30	0.60
6	10.39	0.02	6.70	2.1	0.51
7	6.4	0.04	2.78	4.65	0.54
8	8.58	0.02	4.5	4.60	0.50
9	10.81	0.03	6.20	4.30	0.49

** Concentration of milk - 18%*
*** Process temperature-90ºC*
**** Process duration -90 min.*

Table 3. Ionic composition of the water-soluble part of the dry solid phase of the causticization suspension

Sample numbers correspond to the numbers in Table 1.	Ioncontent, wt%				
	Na^+	Ca^{2+}	OH^-	SO_4^{2-}	CO_3^{2-}
1	0.71	0.04	0.10	0.04	0.72
2	3.11	0.024	0.20	0.21	1.8
3	3.21	0.028	1.21	0.21	1.92
4	2.86	0.036	0.17	0.69	3
5	2.02	0.024	0.44	1.07	1.2
6	2.25	0.036	1.8	1.14	0.36
7	1.7	0.036	0.10	0.21	4.8
8	5.51	0.016	0.13	3.57	4.68
9	5.94	0.028	0.27	3.97	2.04

* Concentration of lime milk - 18%
** Process temperature-90ºC
*** Process duration -90 min.

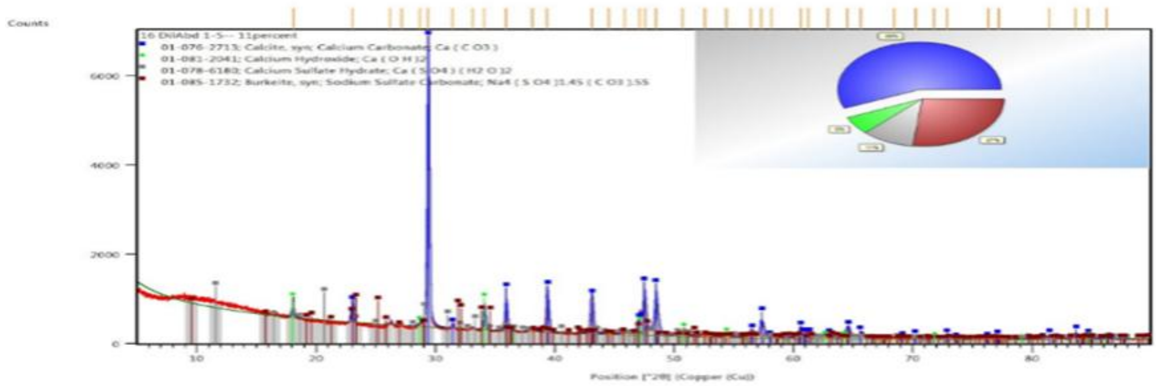


Fig. 4. X-ray pictures of samples. Sample numbers correspond to those in Table 1.

The clarification rate of the suspensions after causticization was high and after 15-30 minutes it was 70%. As a result of clarification, a dense sediment with L:S= 1: 2-4 was formed, which ensured better filtration and washing of the sediment.

Subsequently, after the filtration process with an increase in the degree of evaporation of the liquid phase to 80%, the content of OH^{-}- ions in it (Table 6) gradually increases to 28.29; 19.07 and 28.67%. The content of SO_4^{2-} and CO_3^{2-} ions first increases to reach a degree of evaporation of 40% and then at a degree of evaporation of 80% decreases to 1.01, 0.92 and 0.45 at ratios of $Na_2CO_3 : Na_2SO_4 = 1.0; 0.8: 0.2; 0.5: 0.5$ respectively.

The chemical composition (Table 7) of the sediments consisted mainly of sodium sulfates and carbonates and an insignificant amount of sodium hydroxide. Depending on the conditions of precipitation formation, the content of ions fluctuates in the intervals, (wt.%): $Na^{+} - 22.55 - 48.68; OH^{-} - 0{,}03 - 4.25; CO_3^{2-} - 1.08 - 49.5; SO_4^{2-} - 1.73 - 65.0$[8-9].

As shown by the elemental composition of the samples according to DS (table 8 and Fig. 5), the sludge consists of Ca, O and C and the sediments are from Na, O, S and C.

Microscopic analysis of sediments (Fig. 2) showed the presence of crystals Na_2SO_4 , $Na_2CO_3 \cdot H_2O$ and $Na_2CO_3 \cdot 2Na_2SO_4$ with an average size of 252.3 µm, depending on the technological parameters of the process [10-12].

As the X-ray diffraction pictures of sediment samples (Table 9 and Fig. 6) 3 and 4 show, the sample consists mainly of $CaCO_3$ and $Na_2CO_3 \cdot H_2O$, respectively 61 and 72%, in samples 7 and 10 the content of burkeite is at least 57%.

Fig. 7 shows a derivatogram of causticizing sludge and sediment, which formed during evaporation.

Thermogravimetric analysis of curved (DTG) sludge samples shows that its intensive decomposition is observed mainly in two temperature ranges. The first temperature range of decomposition is 53-244ºC; the second is 255-790ºC (Fig. 7, Table 10).

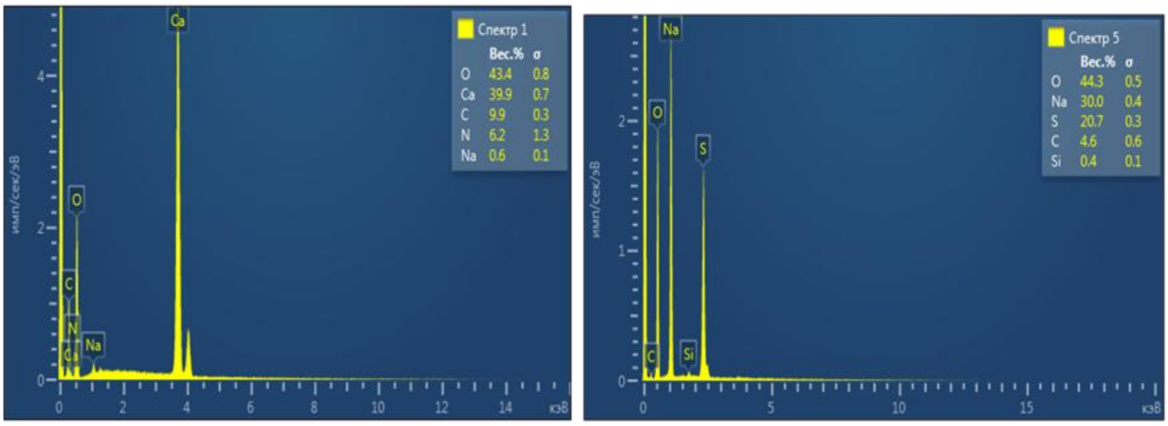


Fig. 5. Energy dispersive spectrum of samples: a) sludge; b) sediment of evaporation

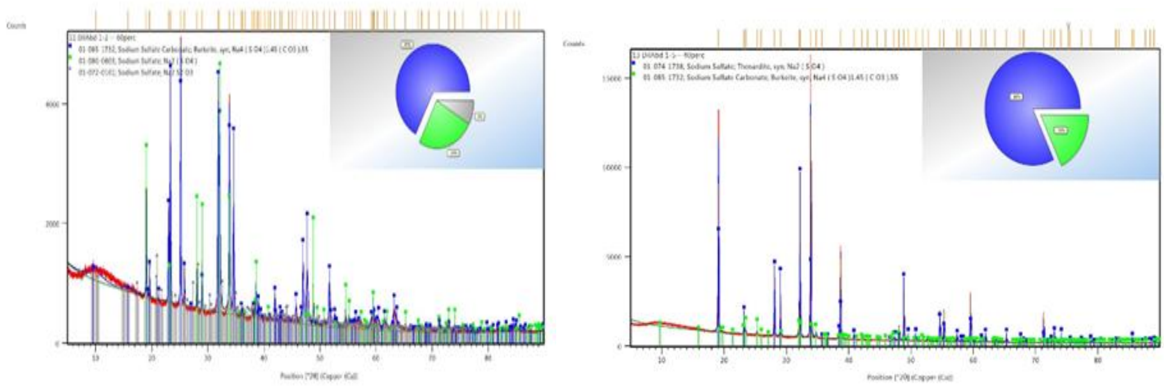


Fig. 6. X-ray pictures of samples. Sample numbers correspond to the numbers in Table 4

Table 4. Influence of the degree of evaporation on the aggregate state of the system and filterability of the formed sediment

№	Ratio Na_2CO_3:Na_2SO_4	Degreeofevaporation,%	The amount of solid phase,%, of the total initial mass	L: S at the end of the evaporation process	Filtration rate, kg / $m^2 \cdot h$	Sedimentmoisture,%
1	1:0	20	Transparentliquid			
2		40	Transparentliquid			
3		60	1.97	19:1	180	27.4
4		80	4.68	3.5:1	280	10.29
5	0,8:0,2	20	Transparentliquid			
6		40	Transparentliquid			
7		60	3.66	10:1	227	23.74
8		80	5.78	3:1	415	8.30
9	0,5:0,5	20	Transparentliquid			
10		40	1.60	38:1	65	17.24
11		60	8.05	4:1	374	12.50
12		80	12.67	0.6:1	971	4.80

Table 5. Mineral content (wt%) in samples

Mineralcodeandname	**Sample numbers***		
	5	**6**	**9**
01-076-2712 $Ca(CO_3)$	81	78	35
01-084-1273 $Ca(OH)_2$	2	17	11
01-078-6180 $Ca(SO_4)\cdot H_2O$	17	5	6
01-085-1732 $Na_2(SO_4)(CO_3)$	-	-	27

**sample numbers correspond to those in Table1*

Table 6. Ionic composition of liquid phase after evaporation

Sample numbers correspond to the numbers in Table 4.	**Ionic composition of liquid phase, (wt%)**				
	Na^+	**Ca^{2+}**	**OH^-**	**SO_4^{2-}**	**CO_3^{2-}**
1	10.31	0.009	5.70	2.01	3.10
2	14.60	0.020	7.60	2.67	4.01
3	19.52	0.009	11.78	2.70	3.02
4	39.22	0.020	28.29	0.04	1.01
5	7.11	0.009	3.77	3.02	0.80
6	10.19	0.021	5.12	4.01	1.81
7	14.78	0.009	8.19	4.92	1.94
8	26.52	0.009	19.07	0.08	0.92
9	8.43	0.025	3.23	5.60	1.81
10	11.33	0.019	4.38	7.46	2.42
11	15.60	0.02	7.79	3.62	4.31
12	39.18	0.019	28.67	0.13	0.45

Table 7. Chemical composition of sediments formed after evaporation

Sample numbers correspond to the numbers in Table 4.	**Ionic composition of the solid phase,%**				
	Na^+	**Ca^{2+}**	**OH^-**	**SO_4^{2-}**	**CO_3^{2-}**
3	44.52	0.08	4.25	1.73	49.5
4	48.68	0.02	1.02	37.28	38.4
7	26.03	0.34	0.34	48.56	3
8	22.55	1.1	1.1	31.03	8.1
10	32.30	0.03	0.03	65.0	1.08
11	32.28	0.17	0.17	64.5	1.5
12	28.63	0.08	3.25	45.73	3.13

Table 8. Elemental composition of samples according to the energy dispersive spectrum of samples

Sample numbers correspond to the numbers in Table 1.	**Content,%**			
	Ca	**Na**	**C**	**O**
Sludge				
6	39.9	6.2	9.9	43.4
9	40.9	3.1	9.5	45.7
Sediment				
Sample numbers correspond to the numbers in Table 4.	Na	C	S	O
8	31.3	8.6	16.1	44
12	30.0	4.6	20.7	44.3

Table 9. Mineral content in samples, wt%

Mineralcodeandname	Samplenumbers.*			
	3	**4**	**7**	**10**
01-078-4615 $Ca(CO_3)$	61	10	-	-
01-078-6180 $Ca(SO_4)\cdot H_2O$	18	11	-	-
01-070-0845 $Na_2CO_3\cdot H_2O$	14	72	-	-
01-074-1085 $Na_2(SO_4)(CO_3)$ H_2O	7	-	-	-
01-088-2051 $Ca(S_2O_4)(H_2O)_4$	-	1	-	-
01-085-1732 $Na_2(SO_4)(CO_3)$	-	-	57	82
01-086-0803 $Na_2(SO_4)$	-	-	26	18
01-072-0161 $Na_2S_2O_3$	-	-	8	-

** sample numbers correspond to those in Table 4*

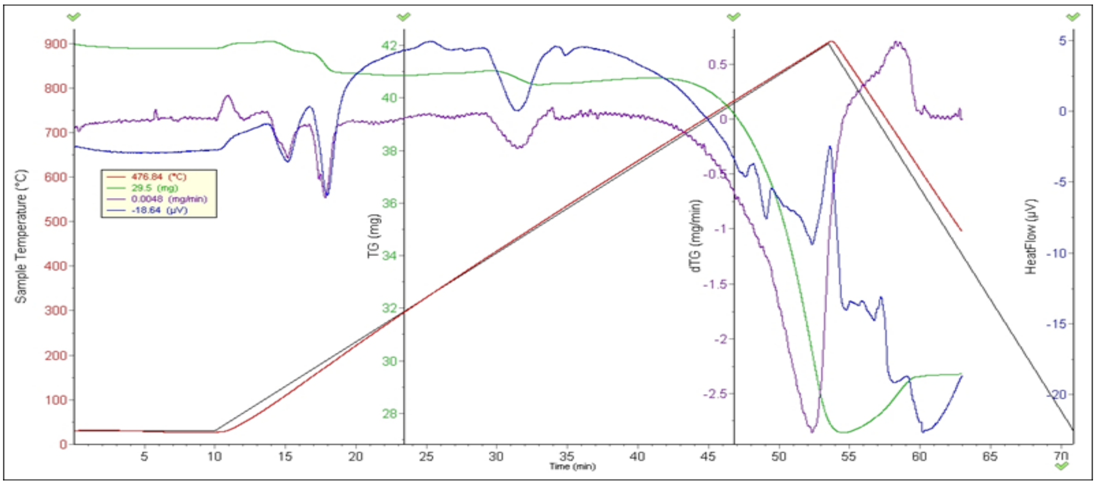


Fig. 7. Derivatogramm of the sample

Table 10. Results of the analysis of DTGA and DSC curves

№	Temperature, °C	Weight loss,%	Decomposition rate of substance, mg / min	Energy consumption (μV·s / mg))
1	50	0.925	0.137	1.45
2	100	1.985	0.465	2.88
3	150	-	-	-
4	800	2.88	0.214	2.55

Intensive decomposition occurs in the second temperature range, where 18.8% of the substance is decomposed.

To calculate and select equipment, as well as to determine the sequence of stages of the proposed production, it is necessary to know the rheological properties of liquids and suspensions formed in the technological stages [13].

Within the studied range of variation of technological parameters, the viscosity and density change in the intervals 4.10-156.5cpz and 1.170-1.517g/sm^3, respectively (Table 11). It should be noted that at 30°C with an increase in the degree of evaporation of more than 60%, a sharp increase in viscosity is observed at all three ratios of $Na_2CO_3 : Na_2SO_4$; however, with an increase in temperature over 60°C, the effect of the degree of evaporation (solution concentration) is leveled. The study of the effect of temperature on the viscosity of the suspension showed that at a ratio of Na2CO3: Na2SO4 -1.8: 0.2 at a temperature of 900C decreased 2.91 times, decreased from 13.28 to 4.56 centipoise, and at a temperature of 300C this indicator decreased by 14.68 times from 111.6 to 7.6 centipoise.

Table 11. Rheological properties of evaporated solutions of caustic soda

Sample numbers correspond to the numbers in Table 4.	Viscosity, cps			Density, g/sm^3		
	30°C	60°C	90°C	30°C	60°C	90°C
1.	17.60	9.5	4.40	1.201	1.190	1.180
2.	17.20	8.81	4.30	1.230	1.218	1.205
3.	29.13	13.01	6.10	1.327	1.305	1.292
4.	156.50	22.5	9.50	1.517	1.505	1.480
5.	13.28	8.81	4.56	1.156	1.142	1.131
6.	16.90	10.11	4.10	1.205	1.193	1.186
7.	26.40	11.70	5.60	1.287	1.275	1.260
8.	111.60	22.20	7.60	1.485	1.457	1.435
9.	14.90	9.11	4.56	1.195	1.187	1.170
10.	16.40	9.20	4.60	1.230	1.217	1.200
11.	18.16	10.11	4.78	1.250	1.240	1.225

4. CONCLUSION

Thus, the conducted studies have established that in the range of mass ratios Na_2CO_3:Na_2SO_4= (0,8-0,5):(0,2-0,5), with a general norm of Ca(OH)$_2$ not more than 100% relative to carbonate sodium, circulation of a circulating solution containing 3-7% $NaOH$.At a temperature at least 95°C for at least 2 hours, a movable with a sufficiently acceptable filtration rate is formed to obtain a weak transparent lye of the composition (wt,%): $Na^+, OH^-, CO_3^{2-}, SO_4^{2-} - 6.07 - 10.81; 2.78 - 6.70; 2.1 - 4.65; 2.1 - 4.65$ and 0.49-0.64, respectively. This allows, during evaporation, to obtain rapidly settling large crystals of $Na_2CO_3 \cdot 2Na_2SO_4$, Na_2CO_3 , Na_2SO_4 and a concentrated sodium hydroxide solution.

The results of studying the rheological properties of transparent filtrates show that it is desirable to pump them at a temperature not lower than 60°C.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Shokin IN, Krashennikov SA. Soda Technologies" M. "Chemistry; 1975.
2. Rant Z. DicErzeugung Von Soda nachdem. Solvay-Verfahren, Saraevo. 1968;540.
3. Tursunova DA, Erkaev AU, Kaipbergenov AT, Begimqulova KG. Studying of mineralogical composition of deposits formed by vaporization caustic soda solution.//Austrian Journal of Technical and Natural Sciences. 2019;7(8):49-56.
4. Tursunova DA, Begdullaev AK, Erkaev AU, Toirov ZK. Study of the process of evaporation of caustic soda solution. // Collection of materials of the 1st international scientific and practical conference "Actual problems of the introduction of innovative equipment and technologies at enterprises for the production of building materials, the chemical industry in related industries" May 24-25, 2019 2nd volume Fergana. 2019;225- 229.
5. Tursunova DA, Erkaev AU, Toirov ZK, Kucharov B.Kh. Investigations of the process of evaporation of obtaining caustic soda by the chemical method in the presence of sodium sulfate. // 2018 yil "Fan va ta'lim tarbiyining dolzarb masalari" Republic of ilmiy-nazariy va amaliy anzhuman materialari. Nukus. 2018;58-59.
6. Zdanovskiy AB, Solovieva EF, Lyakhovskaya EI, Shestakov NE, Shleimovich RE, Abutkova LM. Handbook of experimental data on the solubility of multicomponent water-salt systems. Ed. 2nd, lane. Idop. - Leningrad: Chemistry. 1973;2 –P. 1070.
7. Doebelin N, Kleeberg R. Profex: a graphical user interface for the Rietveld

refinement program BGMN // Journal of applied crystallography. 2015;48(5):1573-1580.

8. Zhukov AF, Kolosova IF, Kuznetsov VV. Analytical chemistry. Physical and physicochemical methods of analysis.-M: Chemistry. 2001;496.
9. Flame photometry: guidelines for laboratory work // Samara SSTU. 2013;13.
10. Kuznetsova GA. Qualitative X-ray phase analysis. Methodical instructions. –Irkutsk. 2005;20-22.
11. Nedoma I. Decoding of powder X-ray diffraction patterns. –M. Metallurgy;1975; 423.
12. Mirkin LI. Handbook for X-ray structural analysis of polycrystals. –M. 1991;863.
13. Kivilis SS. Technique for measuring the density of liquids and solids.- M.: Standard. 1969'70.

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