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JUSTIFICATION OF THE CHOICE OF FLOCCULANTS FOR WASTEWATER TREATMENT AFTER MAGNETIC SEPARATION OF IRON ORES

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Wet magnetic separation is the most common operation in the enrichment of oxidized iron ores (Karmazin 2005, Kirnarsky 2017, Oleynik 2014). Wastewater discharged after separation is a polydisperse suspension with different physicochemical nature of the components. The particle sizes of the suspension are in the range from 3 to less than 0.005 mm, the mass yield of the smallest fraction is from 60 to 90%. The solid phase contains at least 60% silicon oxide, more than 14% iron compounds and 1,8-3,0% dust and clay particles.

After reagentless sedimentation in sludge collectors, partially clarified wastewater is sent to the recycled water pools and after additional sedimentation is reused in production. In ensuring the quality of iron ore concentrates, special attention is paid to the preparation of raw materials, while the influence of the quality of recycled water is practically not considered. However, the recycled water used in the enrichment process contains a large number of fine particles, more than 80% of which have a size of less than 74 microns (Chen et al. 2017 and Jiwei Bian et al. 2018). Reagentless sedimentation method does not satisfy modern requirements due to low-speed deposition sedimentation stable suspensions of fine particle size up to 10^{-6}-10^{-7} m.

The complexity of enrichment for weakly magnetic iron ores is associated with their sludging - fixing of thin (less than 0.5 microns) particles on the surface of ore and non-metallic minerals (Gubin et al. 2016). As a rule, particles of quartz and clay impurities are fixed on ore particles. On non-ore particles are fixed iron hydroxide, hematite, magnetite, siderite and other iron-containing minerals. The process of adhesion of suspensions is intensified at wet enrichment in a strong magnetic field with an induction of 0.6-1.4 T. There is a decrease in the specific magnetic susceptibility of the ore phase and its increase for the non-ore one. Ravinskaya (2019) proposes to process iron ore pulp with ultrasound to eliminate the negative impact of adhering silicate's fine particles with a size of 0.001-0.005 mm. It is noted that the purification of ore and non-ore particles from adhering sludge allows to increase the yield of commercial concentrate by 2.37-4.0% and to increase the extraction of total iron into the concentrate by 3.25-3.45%.

Thus, the high concentration of suspended solids of the source rock remaining in the recycled water makes it difficult to reuse it during enrichment. Therefore, it is advisable to increase the deposition rate of fine particles by adding flocculants to the water, which are widely used in such cases (Spehar et al. 2015, Van Deventer et al. 2011 and Artemiev 2017). With increasing particle deposition rate, the frequency of water turnover cycles increases, which creates favorable economic conditions for existing industries and is of considerable interest for the design of local high-speed thickeners and settling tanks, since it allows to abandon bulky sludge collectors and settling ponds that cause significant harm to the environment.

The aim of the work was to select effective flocculants for clarification of recycled water in the process of wet magnetic separation of iron ore. Types and brands of reagents have been *selected, which allowed radically increasing the rate of deposition of impurities and reducing the turbidity of recycling water.*

***Key words**: recycled water, magnetic separation, purification, flocculants.*

Synthetic organic polymers based on polyacrylamide are widely used as flocculants in the treatment of wastewater and recycled water in the enrichment of minerals (Zhu 2009, Yu 2006 and Yan 2004). Almost all reagents used in this work are modifications of polyacrylamide with a wide range of parameters. Since most of the fine particles suspended in recycled water have a negative charge, cationic polymers are most effective for clarification of such waters (Hasan and Fatehi 2019b).

The variety of factors that determine the course of flocculation complicates the choice of specific reagents and forecasting of the results of their use. Such factors include the nature and dose of the flocculant, its molecular weight, the charge of ionogenic groups, the concentration of the working solution, the degree of dispersion, and the electrokinetic potential of the solid phase. So, it is necessary to conduct research on the recycled waters of existing enterprises to justify the choice of reagents and modes of their use. The results of such studies are considered in this paper.

Purpose, objects and research methods. The aim of the work was to select effective flocculants and optimal conditions for their use for purification of recycled wastewater after magnetic separation of oxidized iron ores. The task was to ensure the minimum turbidity of the purified recycled water while increasing the deposition rate of suspended solids. The objects of research were:

1. Samples of wastewater after wet magnetic separation of oxidized iron ores of the enterprises of the Kriviy Rig basin, the main physical and chemical quality indicators are given in table 1.
2. Industrial samples of flocculants that differ in chemical nature, molecular weight and ionic charge, the main characteristics of which according to (Cationic flocculants of the Zetag® series 2019, Flocculants of the Flopam series 2019, Magnafloc series flocculants 2019, Polyacrylamides of the Ecofloc series 2019] are given in table 2.

Table 1. The main indicators of source water quality

Indicators	Values of indicators for	
	sample #1	sample #2
Turbidity, mg/dm^3	6600	7400
Hardness, mmol/dm^3	33.4	35.3
Alkalinity, mmol/dm^3	2.4	2.7
Dry residue, mg/dm^3	7683	6730
Iron (total), mg/dm^3	950	1000.0
Sulfates, mg/dm^3	948	1126
Chlorides, mg/dm^3	2522	2600
pH	7.3	7.5

Table 2. Investigated flocculants

##	Flocculant brand	Country	Flocculant type	Charge value	Molecular weight
1	Zetag 8125	Germany	Cationic	Weak	High
2	Zetag 8160	Germany	Cationic	Above average	High
3	Zetag 8180	Germany	Cationic	Strong	High
4	Zetag 8190	Germany	Cationic	Very strong	High
5	Ecofloc K16	China	Cationic	Medium high	Average
6	Ecofloc K18	China	Cationic	Strong	Average
7	Праестол TR 650	Germany	Cationic	Average	High

8	Flopam Fo 4140 SH	France	Cationic	Very weak	Very high
9	Magnafloc 10	Germany	Anionic	Average	Very high
10	Magnafloc LT-25	Germany	Anionic	Weak	Very high
11	Magnafloc LT-27	Germany	Anionic	Average	Very high
12	Magnafloc 525	Germany	Anionic	Average	Very high
13	Magnafloc 336	Germany	Anionic	Weak	Very high
14	Magnafloc 919	Germany	Anionic	Weak	Very high
15	Ecofloc AR-3	China	Anionic	Average	High
16	Ecofloc AR-5	China	Anionic	Very weak	High
17	Ecofloc AR-8	China	Anionic	Weak/Average	Average
18	Ecofloc AR-11	China	Anionic	Weak/Average	Very high
19	Ecofloc N2	China	Nonionic	-	Below average
20	Ecofloc N3	China	Nonionic	-	High
21	Magnafloc LT-20	Germany	Nonionic	-	Average

Notes: 1. According to the Gandurina (2007) classification the charge value is characterized by the content of ionogenic groups, %. Anionic type: very weak – (3-10); weak – (10-20); average – (20-50); strong – (50-100). Cationic type: weak – (3-10); average – (20-50); strong – (50-80); very strong – (80-100).

2. Molecular weight according to the Bolto and Gregory (2007) classification: low < 10^5; average – (10^5-10^6); high > 10^6.

As follows from table 1, water is characterized by a very high content of suspended solids (turbidity), correlated with the concentration of iron compounds. The suspension is well precipitated - the turbidity of the water was 20-50 mg/dm^3 after 0.5-1 hour of reagentless sedimentation. Water has a high hardness and contains a significant amount of salts also. It is believed that the salinity for the recycled water of mining and processing industries is not important. However, it is known that at salt concentration is more than 3 g/dm^3, efficiency of ionogenic flocculants decreases and the high molecular weight non-ionic flocculants are more effective.

In technological research and during operation, an important factor is shelf life of reagent solutions. Alkaline conditions promote the hydrolysis of ether groups, which leads to a decrease in the charge density of the reagent. Bolto and Gregory (2007) noted that some degradation of the polymers occurs even at pH 6. In this case almost half of the polymer is hydrolyzed after 24 hours. At pH 8.5, this process occurs after 0.25 hours. The polymer is stable at pH 4 only. In addition to the loss of cationic centers, hydrolysis causes a change in the conformation of the chain due to the formation of anionic carboxyl groups, which reduce the length of the chain and make flocculant less effective.

In view of the above, working solutions of the reagents were used for no more than 2 days, and mother liquors for no more than 14 days. Preparation of mother liquors and working solutions of flocculants was carried out considering the recommendations of Ovcharenko and Golovko (2001) by soaking the reagent with ethyl alcohol and dissolving in distilled water while shaking on a Schuttel apparatus. 0.5% mother liquors were obtained as a result. For investigation used 0.05, 0.025 and 0.01% working solutions, prepared by diluting mother liquor with distilled water, in the pH range 5.4-6.6.

Investigation results for sedimentation of impurities of the source water. A preliminary assessment of the sedimentation of impurities of the source water without the use of flocculants was carried out, to assess the basic conditions of the studies. For this purpose, the sedimentation curves showing the percentage of deposition of the initial polydisperse suspension (P,%) over the settling time (T, sec) were obtained with method described by Kulskiy (1980) using torsion weights. An example of such a curve is shown in Fig. 1 (sample #1, Table 1). From its consideration, it follows that the bulk of the particles (>80%) settles in the first 3 minutes of reagentless sedimentation, whereas up to 10 minutes are needed to precipitation smaller fractions. At the same time, the water retains opalescence caused by very small particles.

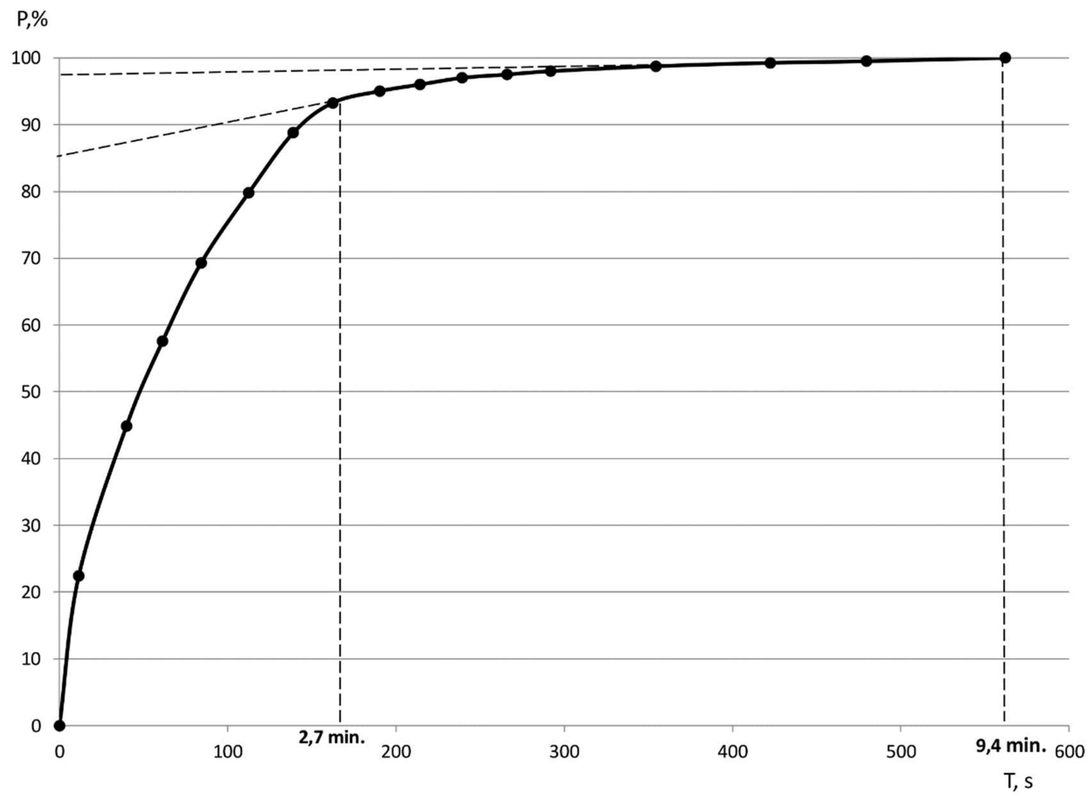

Fig. 1. Sedimentation curve for sample #1.

In our case, it is impossible to estimate the dispersed composition of suspended particles by sedimentation curves and apply the Stokes equation due to the uncertain density of the solid phase components. This problem becomes more unsolvable for amorphous flocs formed by flocculants. Therefore, to assess the deposition for such a system, the curves of the «percentage» mass deposition of suspension (P) *vs* on the hydraulic fineness (W_{HF}) determined experimentally, examples for the studied samples of effluents and their mixtures are presented in Fig. 2.

The hydraulic fineness was determined as h/t, where h is the depth of immersion of torsion balance cup, t is the time of sediment accumulation on the cup. From Fig. 2 it follows that W_{HF} of suspended particles is in a wide range - from 0.1 to 8 mm/s. Up to 30% of the suspension has W_{HF} from 8 to 2 mm/s. The W_{HF} section from 2 to 1 mm/s is characterized by a significant bend. The proportion of particles with such hydraulic fineness is about 30%. More than 40% of the particles have a W_{HF} from 0.1 to 1 mm/s. The minimum hydraulic fineness measured in the experiments was 0.10-0.15 mm/s. Obviously, it is the fractions of particles with $W_{HF} \leq$ 0.10-0.15 mm/s that create residual turbidity and background opalescence after the reagentless sedimentation of wastewater.

A comparison of these data with known information from chemical technology (Chemist's Directory 21 2019) allows us to classify residual wastewater contaminants as sludge and fine sludge, having a fraction size from 0.005 to 0.050 mm. For effective particle diameters of 0.008 and 0.010 mm, the calculated hydraulic fineness are 0.098 and 0.154 mm/s, respectively, which practically coincides with the data of Kulskiy (1980) for most mineral suspensions.

Thus, to achieve this goal, it was necessary to choose the samples flocculants, listed in table. 2, that are most effective in the deposition of contaminants with hydraulic fineness $W_{HF} \leq 0.10\text{-}0.15$ mm/s. A practical assessment of this efficiency was carried out according to the residual turbidity of the settled water C_t, where t is the settling time, minutes.

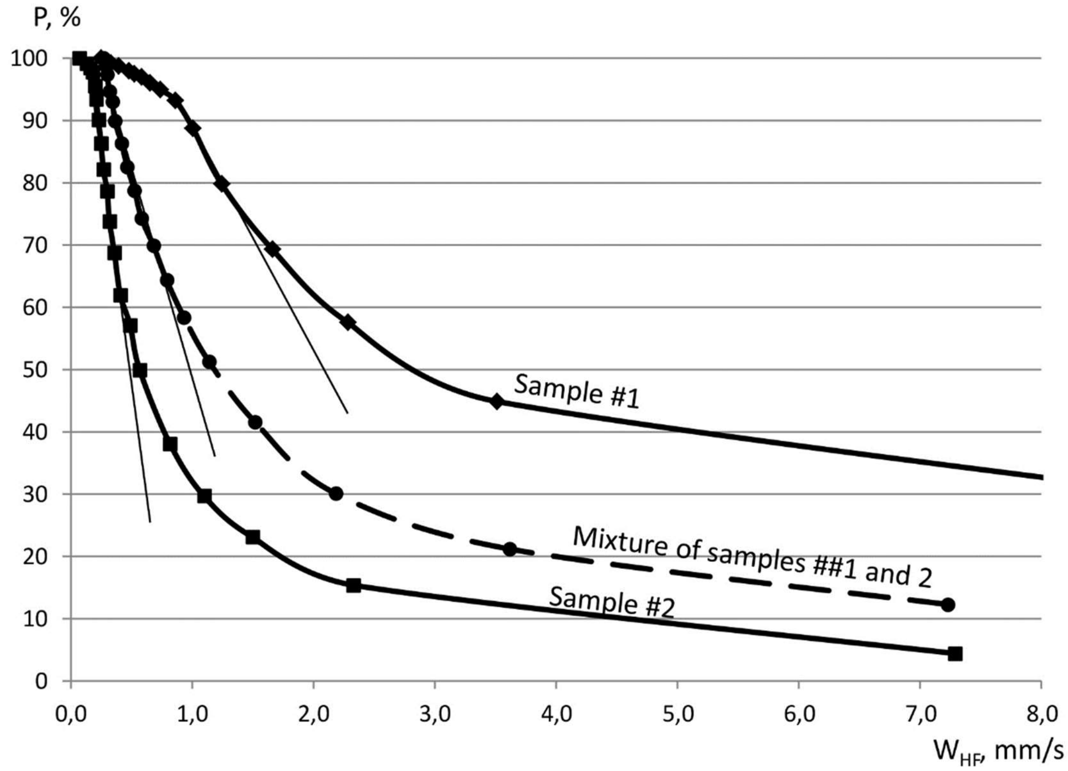

Fig. 2. Curves of the percentage deposition of suspended particles from their hydraulic fineness

The results of the sedimentation test in the cylinders. The main studies were carried out in «soft» hydraulic conditions by free deposition of flocculated suspension in cylinders. The deposition rate of the bulk of the impurities W_s was determined by visual fixation of the passage of the sediment surface of the corresponding marks (divisions) of the cylinder. Strictly speaking, this speed was not hydraulic fineness W_{HF}, although it correlated with it. It can be considered as the average rate of constrained deposition of the smallest fractions. For the initial wastewater according to different experiments, W_s was 0.19-0.25 mm/s.

Table 3 shows the average test results of the flocculant samples indicated in table 2, applied with a dose of 2 g/m^3. As can be seen from the data, none of the anionic type samples (positions 9-18, table 3) did not provide turbidity of water C_5 less than 10 mg/dm^3. At the same time, the settled water was strongly opalescent. Cationic and nonionic flocculants provided much greater clarification with the same order of deposition rates. These differences are explained by the physicochemical nature, electrokinetic properties and fractional composition of suspended solids and the properties of the reagents used.

Table 3. Results of sedimentation tests of flocculant samples

##	Flocculants		Research results				
	Brand	Type	W_s, mm/s	Increase W_s, times	C_5, mg/dm^3	Reduction C_5, times	V_s, ml
0	Without flocculant		0.25	-	500	11	-

1	Zetag 8125	+	22.84	91	9.85	558	22.5
2	Zetag 8160	+	13.14	53	8.35	659	35.0
3	Zetag 8180	+	8.35	33	12.95	425	12.5
4	Zetag 8190	+	23.16	93	9.15	601	32.5
5	Ecofloc K16	+	9.90	40	10.00	550	30.0
6	Ecofloc K18	+	19.35	77	8.45	651	32.5
7	Praestol TR 650	+	9.89	40	23.85	231	22.5
8	Flopam Fo 4140 SH	+	29.02	116	4.40	1250	20.0
9	Magnafloc 10	-	59.70	239	15.50	355	37.5
10	Magnafloc LT-25	-	12.59	50	18.25	301	15.0
11	Magnafloc LT-27	-	5.35	21	31.45	175	10.0
12	Magnafloc 525	-	17.97	72	21.60	255	25.0
13	Magnafloc 336	-	18.08	72	14.25	386	22.5
14	Magnafloc 919	-	3.83	15	23.00	239	10.0
15	Ecofloc AR-3	-	11.90	48	19.50	282	15.0
16	Ecofloc AR-5	-	8.82	35	41.70	132	25.0
17	Ecofloc AR-8	-	10.59	42	14.45	381	20.0
18	Ecofloc AR-11	-	36.81	147	20.85	264	35.0
19	Ecofloc N2	0	14.92	60	12.60	437	32.5
20	Ecofloc N3	0	16.86	67	8.05	683	25.0
21	Magnafloc LT-20	0	16.33	65	7.05	780	22.5

Note: Flocculant type: «+» – Cationic; «-» – Anionic; 0 – Nonionic.

In recent works Hazan and Fatehi (2018, 2019a) were shown that the adsorption, ζ-potential and flocculation efficiency depend on the charge density and molecular weight of lignin-acrylamide flocculants used to clarify clay suspensions. The higher charge density of the copolymer caused its higher adsorption on kaolin and bentonite particles and led to a significant decrease in the turbidity of the clay suspension. As is known, there are two possible mechanism for action of high molecular weight polymers - the formation of bridges and/or charge neutralization, including the mechanism of electrostatic «patch» (Bolto and Gregory 2007). In accordance with the «bridge» mechanism, flocculation of suspensions proceeds in two stages: adsorption of macromolecules of flocculant on particles of the dispersed phase and binding of these particles by polymer bridges into aggregates (floccules). The electrokinetic mechanism assumes that negatively charged macromolecules of anionic flocculants are sorbed on oppositely charged particles of relatively heavy ore minerals, interact with free particles and in the composition of the formed floccules settle at a high rate. The solution remains opalescent part of negatively charged superfine particles of silicate minerals.

In a study of the effectiveness for two types of starch-based flocculants by Haijiang Li et al. (2015), suspensions of hematite and kaolin, whose charge is opposite to that of flocculants, were used. Based on the change in ζ-potential of the particles was found to be the main mechanism of clarification in this case was the neutralization of particle's charge. Moreover, bridge formation also made a corresponding contribution to the efficiency of flocculation.

Depending on the composition of the dispersion medium and the salt content, the electrokinetic potential of quartz is -(35.6-58.2) mV. In clay suspensions in the absence of salts in the solution, the value of the ζ potential of the particles reaches -(24-33) mV. In the presence of mono- and divalent ions in the suspension, the ζ-potential of the particles drops to about -10 mV (Chelyshkin 2000). This explains the combination of high deposition rates and high residual turbidity after application of anionic flocculants with very high molecular weights - Magnafloc 10 and Ecofloc AR-11 (positions 9 and 18, table 3). They are also characterized by a relatively large volume of sediment V_s, which visually looked loose with a fuzzy («blurred») surface. Such flocculants can be used effectively where there are no high requirements for turbidity.

Research by Ying Zhou et al. (2008) on the interaction with quartz particles of cationic flocculants with charge densities of 10, 40 and 100% and a molecular weight of $3{,}0\cdot10^5$, $1{,}1\cdot10^5$ and $1{,}2\cdot10^5$ g/mol showed that the most effective are flocculants with a charge density of 40 and 100%. These flocculants act by a mechanism of neutralization or patch attraction. In our case six samples of cationic flocculants met the requirements for residual turbidity ($C_5 \leq 10$ mg/dm^3). The high efficiency of cationic flocculants is explained by the fact that at the first stage positively charged molecules of flocculants are effectively sorbed on negatively charged particles of silicate minerals, binding them into floccules with large hydraulic fineness. Unsatisfactory residual turbidity for cationic flocculants Zetag 8180 and Praestol 650 (positions 3 and 7, table 3), possibly related to the recharging of the electrokinetic potential of the particles from negative to positive values. This is primarily due to the low values of the ζ potential in the water-salt medium and, accordingly, with increased sensitivity to changes in the dose of the flocculant, which contributed to an increase in the aggregative stability of the suspension due to restabilization.

In contrast to the anionic and cationic flocculants discussed above, the effectiveness of nonionic flocculants is determined only by the «bridge» mechanism, i.e. depends not on the surface charge of the dispersed phase, but on the molecular weight of the reactants. For the separation of the majority of suspensions homogeneous in dispersion, there is a pattern: the higher the molecular weight of the flocculant - the more effective its action. In the case of polydisperse suspensions, there is a relationship between the molecular weight of the flocculant and the fractional composition of the dispersed phase. In this case, it should be noted sufficiently high efficiency water clarification samples Ecofloc N3 and Magnafloc LT-20 (positions 20 and 21, table 3) at high deposition rates contaminants.

The five best flocculant samples were selected for further research according to combination of the resulting C_5 turbidity and W_S deposition rate: cationic - Flopam Fo 4140 SH, Zetag 8160, Ecofloc K18 and nonionic - Ecofloc N3, Magnafloc LT-20 (respectively, positions 8, 2, 6, 20 and 21, table 3).

Results of jar tests for selected flocculants. Jar tests were carried out on the flocculator in «hard» conditions, close to the conditions of water supply to the sludge collectors. The efficiency of water purification in such conditions is influenced by the dose of flocculant, hydrodynamic conditions of mixing, formation and settling of flocculants. Considering the actual modes of wastewater transportation, the following parameters of flocculation are accepted: 1 minute – dosing and mixing of the flocculant with water at a stirrer speed of 300 rpm; 10 or 30 minute – with stirring speed stirrers 150 rpm; 15 minutes – sedimentation and sampling.

In Figure 3 presented flocculation curves, which show that for almost all samples the optimal dose is 2 g/m^3, which after 15 minutes settling ensured turbidity C_{15} 1.5-2 mg/dm^3. A little worse showed Flopam Fo 4140 SH (C_{15}=2.6 mg/dm^3), however it «worked» at a dose of 1 g/m^3.

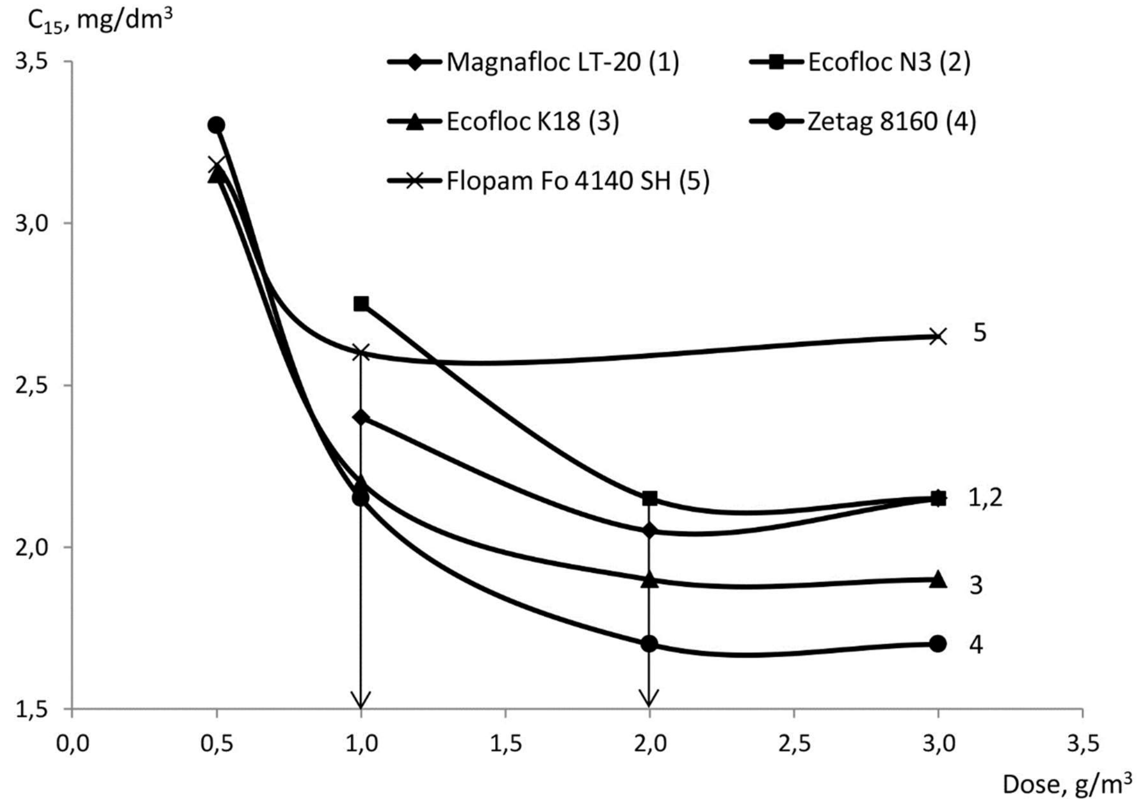

Fig. 3. Kinetics of flocculant dose effect on water turbidity changes.

The average results presented at in Fig. 4, show that the best combination of indicators W_s and C_{15} provide nonionic flocculant Magnafloc LT-20 and cationic flocculant Zetac 8160.

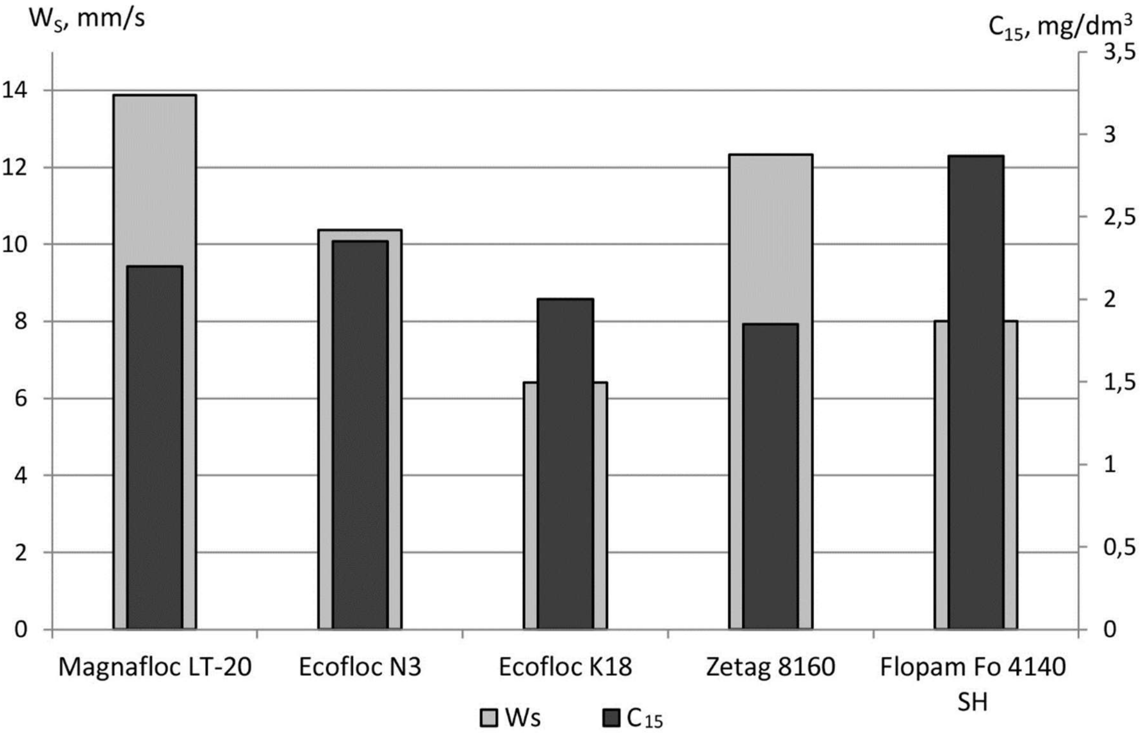

Fig. 4. Average results for selected flocculants.

In the case of nonionic flocculants Magnafloc LT-20, Ecofloc N3 and cationic flocculant with a very weak charge – Flopam Fo 4140SH, floccules are formed within 20-40 seconds. By reducing the mixing speed in the second stage to 150 rpm for 2-5 minutes, these floccules are enlarged, but as shown in Fig. 5, the suspension is stratified into the upper part from large flocs, middle - transparent water and the lower from settled particles. Then, after 5-10 minutes of stirring, the floccules fill the entire volume of the glass again. There are two possible mechanisms explaining this phenomenon - restabilization and/or repeated destruction of flocs.

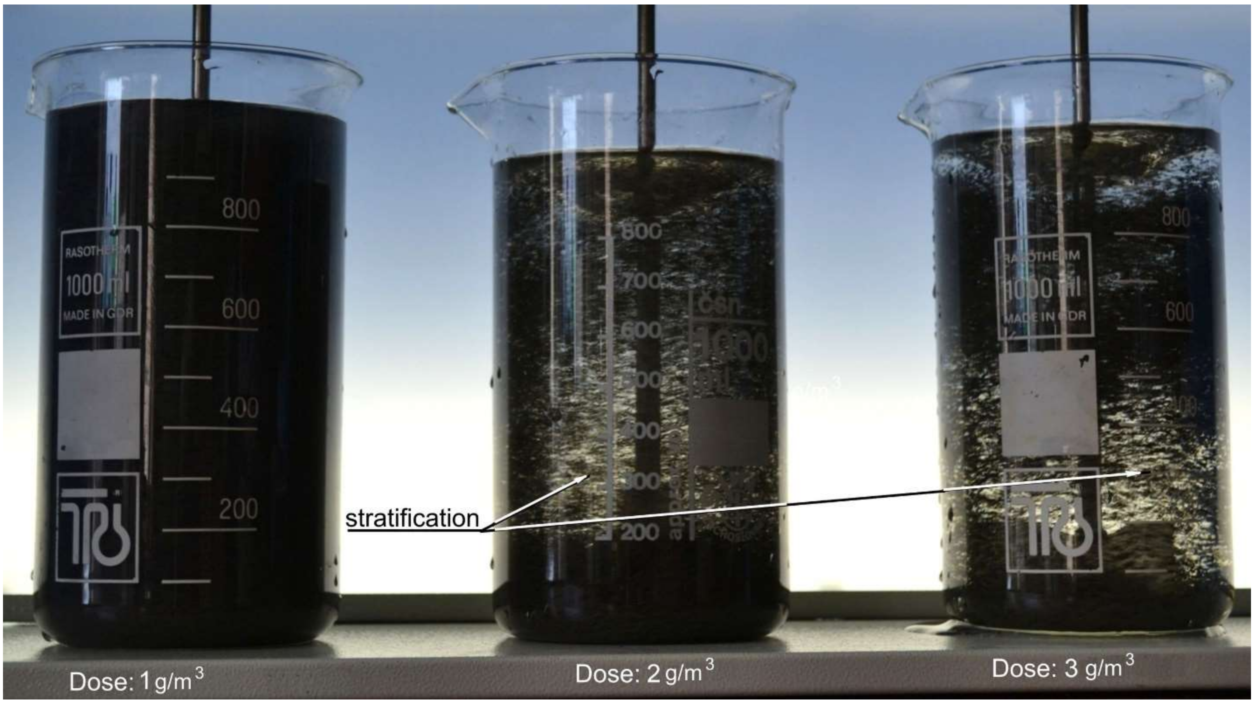

Fig. 5. Stratification of floccules in the depth of the glass (flocculant Flopam Fo 4140SH).

In the case of bridged flocculation, which is most likely for nonionic and weakly charged cationic flocculants, floccule stabilization is possible due to the high coverage of the particle surface with adsorbed flocculant chains. The resulting floccules grow to an equilibrium size, which depends on the stirring speed, but their growth is limited by the conditions of destruction with increasing speed and they cannot be easily restored when they return to their former conditions (Bolto and Gregory 2007). Destruction of floccules can be irreversible and is caused by various aspects of the state of polymer chains under turbulent conditions or separation of adsorbed polymer segments due to desorption.

Such a factor as the stirring time at the second stage is important from the point of transportation of water with added reagents to the close and far discharges of wastewater into sludge collector. In our case, the transportation time is from 10 to 30 minutes. To assess the potential risk from the destruction of flocculants, an experiment was carried out using a cationic flocculant with a very weak charge Flopam Fo 4140SH at a dose of 2 g/m^3 and a stirring time of 10 and 30 minutes at the second stage.

The results are given in table 4, which shows the change in the deposition rate of W_s at different marks on the depth of the glass. After stirring for 30 minutes W_s were 2 times lower than after stirring for 10 minutes, other conditions being equal. Turbidity C_5 is amounted to 5.3 и 2.6 mg/dm^3, respectively. The same nature of the change in water turbidity was shown after 2 hours and after 2 days of sedimentation, which generally indicates the action of the mechanism of repeated destruction of floccules without their restabilization.

For cationic flocculants Ecofloc K18 and Zetag 8160 with a «medium-high» charge, the process of formation and destruction of floccules is extended over time. After 30 minutes of stirring, the corresponding deposition rates of W_s were 6.7 and 11.1 mm/s, residual turbidity C_5 was 1.9 and 1.7 mg/dm^3.

Table 4. Action of various modes of water treatment with flocculant Flopam Fo 4140SH

Depth from water surface H, mm		W_s, mm/s for stirring time	
		10 minutes	30 minutes
0		0	0
30		6.98	3.33
60		8.05	3.77
90		8.08	3.89
120		7.47	3.61
C, mg/dm^3, in	5 minutes	2.6	5.3
	2 hours	2.9	6.8
	2 days	2.7	3.5

Summary. Wastewater formed after wet magnetic separation of oxidized iron ores is a polydisperse suspension with a suspended particle content (turbidity) of 6.6-7.4 g/dm^3. The hydraulic fineness of suspension particles ranges from 0.1 to 8 mm/s at a deposition rate of fine suspensions of 0.19-0.25 mm/s. The problem is sedimentation-resistant pollution, having a hydraulic fineness up to 0.10-0.15 mm/s, corresponding to an effective particle diameter up to 8-10 microns. They practically do not precipitate, providing stable opalescence of water.

From the above information analysis of the study's results on flocculation of fine suspensions from particles of clay, hematite and quartz, it is seen that flocculation is the most appropriate method for intensifying the clarification for such waters. The optimal type flocculants are cationic polymers having high molecular weight and charge density, allowing to implement the mechanisms of charge neutralization or patch attraction, and bridge formation. In the case of using nonionic flocculants, the main role in flocculation is played by the high molecular weight of the polymer, which determines the action of the bridging mechanism.

To intensify the precipitation's process of impurities for real wastewater formed in the process of wet magnetic separation of iron ores, a number of flocculants differing in the charge of ionogenic groups and molecular weight were studied. As a result of sedimentation testing, the most effective were cationic flocculant with a very low charge value and a very high molecular weight Flopam Fo 4140 SH, cationic flocculant with a high charge value and a high molecular weight Zetag 8160 and non-ionic flocculant with an average molecular weight Magnafloc LT-20. These samples allowed to increase the deposition rate of suspended solids in 53-116 times and reduce the turbidity of water by 659-1250 times - down to 4.4-8.4 mg/dm^3. In evaluating these flocculants using jar-tests in the «hard» hydrodynamic conditions approaching production, the most effective proved to be cationic flocculant Zetag 8160, the process of formation and destruction of floccules for which is stretched over time. This choice is in good agreement with the well-known ideas about the mechanism and features of the action of ionic and nonionic flocculants under similar conditions.

The obtained results of reducing the residual turbidity of recycled water can be applied to improve the quality of magnetite concentrate. Increasing the sedimentation rate of suspended solids will increase the frequency of water circulation cycles, which will create additional conditions for the expansion of production using the same volumes of source water. The results can also be used to design local high-speed thickeners and settling tanks instead of bulky sludge collectors and ponds that cause great harm to the environment.

ОБГРУНТУВАННЯ ВИБОРУ ФЛОКУЛЯНТІВ ДЛЯ ОЧИЩЕННЯ СТІЧНИХ ВОД ПІСЛЯ МАГНІТНОЇ СЕПАРАЦІЇ ЗАЛІЗНИХ РУД

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У забезпеченні якості залізорудних концентратів особлива увага приділяється підготовці сировини, тоді як вплив якості оборотної води практично не розглядається. Однак наявність в оборотній воді тонких частинок рудних шламів або глинистих матеріалів, що закріплюються на поверхні рудних і нерудних мінералів, негативно впливає на процес збагачення. Одним з найбільш ефективних методів прояснення таких вод є використання високомолекулярних синтетичних флокулянтів. Проте різноманіття марок флокулянтів і факторів, що визначають процес флокуляції, ускладнює вибір реагентів і прогнозування результатів їх використання. Для цього необхідне проведення досліджень на стічних водах діючих підприємств. Метою цієї роботи був вибір ефективних флокулянтів для прояснення проб оборотної води, відібраних на відповідних підприємствах в процесі мокрої магнітної сепарації залізних руд. Методами седиментаційного аналізу в циліндрах і проведенням джар-тестів досліджено двадцять один промисловий зразок катіонних, аніонних та неіоногенних флокулянтів, які є модифікаціями поліакриламіду. Встановлено, що для очищення таких вод найбільш ефективними є катіонні флокулянти Flopam Fo 4140 SH і Zetag 8160, а також неіоногенний флокулянт Magnaflоc LT-20, які дозволили при оптимальній дозі 1,5 мг/дм^3 збільшити швидкість осадження домішок в 53-116 разів і в 659-1250 разів знизити каламутність оборотної води. Результати роботи можуть бути використані для інтенсифікації процесу очищення оборотної води при мокрій магнітній сепарації окислених залізних руд, а також проектування локальних швидкодіючих відстійників замість громіздких шламонакопичувачів, що завдають великої шкоди навколишньому середовищу.

Ключові слова: *магнітна сепарація, оборотні води, очистка, флокулянти.*

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