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IMPROVEMENT OF REAGENT MODES OF COAL SLUDGE FLOTATION

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As is known, about 230 million tons of coal are mined in Kuzbass, of which 70 million are coking grades, which are enriched with a depth of up to 0, due to the use of sludge flotation. In addition, sludge and energy grades are flown on many coal beneficiation plant. Considering that flotation receives an average of 15% of the material from ordinary coal, and the specific consumption of flotation reagents averages 1.5 kg/ton of sludge, the annual market for consumption of flotation reagents in Kuzbass is ~ 15-20 thousand tons. The volume of enriched sludge by flotation is 11 million tons per year. Therefore, the contribution of flotation methods to the coal processing industry cannot be overestimated.

This report discusses the issues of improving the flotation properties of reagents, which are achieved by optimizing the component composition, physical effects on the reagent and improving the method of supplying the reagent, while reducing the cost of the reagent.

Apolar reagents, which are petroleum products, such as kerosene, diesel fuel, terogazoil and others, boiling at temperatures up to 350 °C, have been widely used as a collector during coal flotation. At the same time, there are a large number of petroleum products on the global market, boiling at high temperatures, which are not used as flotation reagents due to low flotation activity.

From this point of view, secondary (recycling) mineral oils are of great interest, which are formed in large quantities in various industries and low price. The use of spent petroleum products as part of the collector is promising from an economic and environmental point of view, since it allows you to significantly reduce the cost of reagents, as well as recycle secondary hydrocarbon raw materials.

The analysis of the component composition of secondary mineral oils and classical reagents showed that the basis of both those and other petroleum products are marginal hydrocarbons (Table 1). The absence of a fundamental difference in the component composition of these products suggests that the composition itself is not the cause of low flotation activity and spent mineral oils can serve as raw materials for the production of apolar reagents. But for this, it is necessary to establish the reasons for the low flotation activity of oils and develop ways to eliminate this disadvantage.

Table 1

Composition of collecting reagents and mineral oils

	Kerosene	Terogazoil	Turbine oil	Transformer oil	Motor oil
Group composition, % (wt.)					
Saturated:					
Paraffin	-	7-10	10-15	-	20-22
Aliphatic	20-60	25-30	18-20	35-50	40-45
Naphthenic	20-50	10-15	34-40	25-40	10-11
Aromatic	5-25	45-50	35	8-20	23-24
Unsaturated	2	2,5	1,5	2	1-2

To find the reason for the low flotation activity of oils, consider the basic physico-chemical properties using the example of the following products (Table 2):

- Used engine oil (UEO)
- A mixture of thermal oil and used engine oil 50/50% by weight.

Table 2

Characteristics of oil reagents

Name	Viscosity, mm^2/sec	Density, kg/m^3	Surface tension at the liquid-liquid interface, 10^{-3} Newton/metre	The marginal wetting angle of the reagent droplet on the surface of coal in water measured through the oil phase, degrees
UEO	112	873	38,3	107
Mixed (Terogazoil + UEO)	16,7	905	34,6	86

The main difference is the significantly higher viscosity of the UEO

It is known that all apolar collectors are practically insoluble in water and act in a drip form, while their effectiveness depends on the dispersed composition of oil droplets. The greater the dispersion of the reagent emulsion and the more uniform its composition, the higher its efficiency.

We assume that petroleum products with higher viscosity, other things being equal, disperse worse, and fixed drops of reagent on the surface of coal spread worse, i.e. the wetting edge angle is more viscous products – more.

The next step was to evaluate the ability of the proposed compositions to transition to a dispersed state at different intensities of the external fur. impacts. To do this, an emulsion of reagents in water was prepared at different speeds of the agitator - 1000, 2500 and 4000 rpm. The results of measurements of the dispersed composition of emulsions are shown in Figure 1.

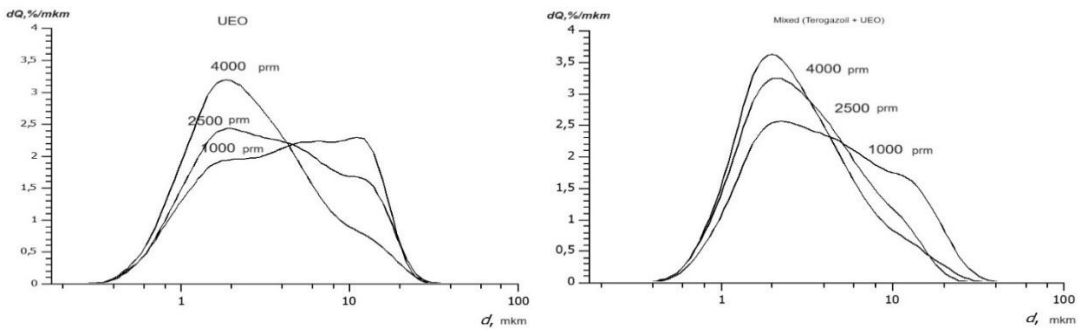

Figure 1. Distribution of droplets of the UEO emulsion and the UEO + terogazoil mix by size, at a dispersion intensity of 1000, 2500 and 4000 rpm.

It can be seen from the figures that with an increase in the intensity of mixing, the uniformity of the emulsions increases significantly, and the number of large droplets decreases sharply. The results are valid for both pure UEO and a mixture of thermogasoil with UEO.

Next, the effect of the obtained emulsions on the results of coal sludge flotation was evaluated. Flotation studies were carried out on two brands of sludge: «slightly sintering» and «coke slightly sintering» (Russian classification) Coals differ markedly in their floatability, granulometric composition and ash content (Table 3). The results of the flotation are shown in Figure 2.

Table 3

Granulometric composition of slurries

Size classes, мм	grade coal «slightly sintering»		grade coal «coke slightly sintering»	
	γ, %	A^d, %	γ, %	A^d, %
+ 0,045	27,9	12,7	67,9	9,3
- 0,045	72,1	38,0	32,1	23,3
Total	100,0	30,9	100,0	13,8

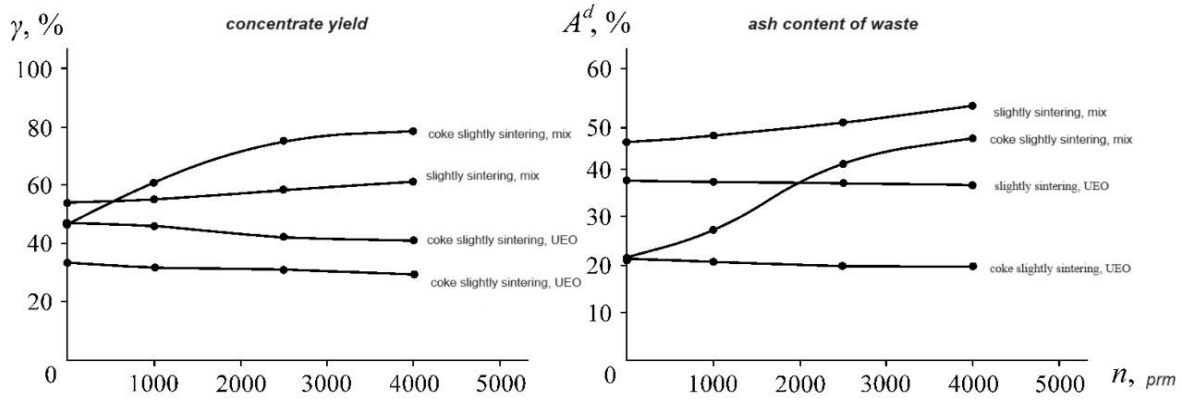

Figure 2. The effect of the mixing rate on the concentrate yield and ash content of waste during flotation of «coke slightly sintering» and «slightly sintering» grade coal, UEO emulsion and UEO + terogazoil mix

When using a mixture of reagents, the positive effect of emulsification of oil reagents on flotation parameters is confirmed by increasing the number and reducing the size of reagent droplets in the pulp and their more uniform adsorption on the surface of coal particles. With an increase in the dispersion of the emulsion during the flotation of «coke slightly sintering» grade coal, the concentrate yield increased by 32%, and the ash content of waste increased by 25%. A less noticeable improvement in flotation indicators is observed on «slightly sintering» grade coal: concentrate yield increased by 6%, and ash content of waste increased by 8%.

A completely different picture is observed when flotation of coals of both brands with UEO emulsions – oil emulsification negatively affects the results of flotation. The main reason for this phenomenon can be considered poor wettability of the coal surface with viscous oil. When a contact is formed between an oil drop and a coal particle, the spreading of the droplet is prevented by hysteresis forces arising in thin layers of viscous oil.

Therefore, one of the main reasons for the low flotation activity of oils is their high viscosity.

However, the use of oil in the form of a mixture with kerosene-gas oil fractions with an oil content of no more than 40% makes it possible to obtain an effective collector comparable to diesel fuel, especially in combination with effective dispersion of reagents.

Another promising way to increase the flotation activity of oils can be considered the addition of an alcoholic solvent with low surface activity. Figure 3 shows a sharp decrease in the viscosity of the oil-solvent mixture. For example, with an alcohol solvent content of 20%, the viscosity of the mixture is reduced by more than two times. At the same time, the yield of the flotation concentrate increases from 5 to 45%, which corresponds to the flotation activity of diesel fuel.

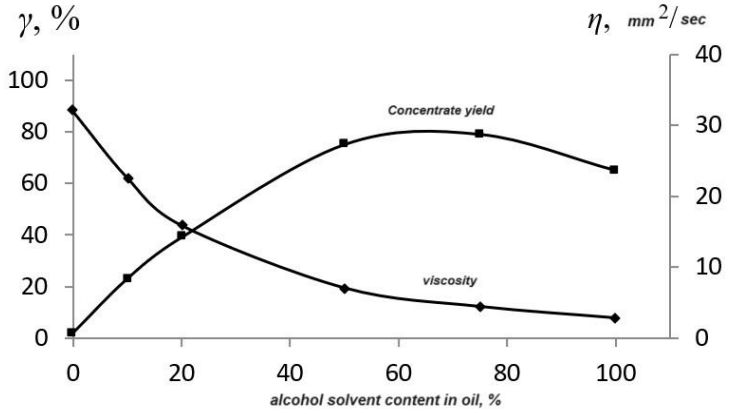

Figure 3. Effect of alcohol solvent additives on oil viscosity and concentrate yield

An additional opportunity to increase the flotation activity of mineral oils appears as a result of oxidative modification of the oil using ozonation. The UEO sample was ozonated with oxygen at room temperature and atmospheric pressure in a bubbling reactor.

A comparison of the flotation activity and selectivity of the initial engine oil sample before and after its ozonation was evaluated based on the results of sludge flotation of various brands. The results of the experiments are shown in Table 4.

Table 4

Results of coal flotation enrichment using the original and ozonated UEO

Reagents		Coal		Concentrate				Wastes				Ad, %	selectivity
				γ, %	A^d, %	E, %	C, г/л	+ 0,045 мм		- 0,045 мм			
UEO	kg/t	brand	A^d, %					γ, %	A^d, %	γ, %	A^d, %		
norm	4,8	OS	12,1	73,7	6,9	78,1	140	17,4	10,0	8,9	59,1	26,7	0,23
ozon			11,9	91,4	6,8	96,6	172	2,7	29,6	5,9	82,1	65,5	0,67
norm.	**3,7**	**F**	**17,1**	**53,4**	**11,4**	**57,1**	**97**	**28,2**	**8,3**	**18,4**	**47,0**	**23,6**	**0,15**
ozon			**17,1**	**65,8**	**10,6**	**71,0**	**109**	**20,7**	**10,7**	**13,5**	**59,0**	**29,7**	**0,23**
norm	3,6	C	16,1	52,4	10,9	55,6	86	25,5	9,3	22,1	36,4	21,9	0,13
ozon			16,0	57,4	10,6	61,1	84	21,4	10,5	21,1	36,4	23,4	0,15
norm	4,1	CSS	21,3	29,9	17,1	31,6	60	40,9	8,8	29,1	43,3	23,1	0,08
ozon			20,8	39,9	14,4	43,1	81	37,1	8,3	23,0	51,9	25,0	0,13
norm	6,2	G	20,6	40,3	13,8	43,8	48	21,3	5,9	38,4	35,9	25,2	0,14
ozon			20,8	53,6	12,7	59,0	53	16,9	6,7	29,5	43,4	30,1	0,22
norm	3,6	Sk	27,7	32,9	20,0	36,4	61	40,4	18,9	26,7	50,3	31,4	0,16
ozon			27,1	43,4	18,4	48,6	70	34,2	19,2	22,4	55,8	33,7	0,21
norm	3,5	SS	19,8	32,5	16,4	33,8	8	35,0	7,5	32,6	36,5	21,5	0,06
ozon			20,0	51,0	14,0	54,8	14	27,8	9,2	21,2	48,6	26,3	0,15

Ozonation of the oil collector makes it possible to improve the technological performance of coal sludge flotation on all brands. For example, for F-grade coal, after ozonation, the yield of flotation concentrate increased by 12.4% with a decrease in its ash content by 1.2%, and the selectivity of the process almost doubled.

One of the effective and proven ways to intensify coal flotation is the effective preparation of the pulp before flotation by the method of oil aeroagglomeration (OAA), during which hydrophobic aggregation of the smallest coal particles with oil reagents is achieved by increasing the oil-water interface in the form of oiled air bubbles. With intensive mixing of the coal pulp, coal particles are fixed at high speed on the surface of small oiled bubbles, forming stable carbon-oil aerocomplexes, which are easily separated from the mineral pulp by subsequent flotation.

All of these methods, especially those used together, make it possible to at least increase the yield of flotation concentrate by a significant amount while maintaining its quality, and at most significantly reduce the cost of the enrichment process by using secondary high-boiling petroleum products as part of collectors.

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