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КОМБИНИРОВАННЫЕ ПРОЦЕССЫ ПЕРЕРАБОТКИ МИНЕРАЛЬНОГО СЫРЬЯ: ТЕОРИЯ И ПРАКТИКА

СПЕЦИАЛЬНЫЙ
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ПЕРЕРАБОТКА ЗОЛОУНОСА ТЕПЛОЭЛЕКТРОСТАНЦИИ

Исследованы возможности извлечения недожога из летучей золы (золы уноса) Старобешевской ГРЭС методом флотации. Рассмотрено влияние алюмосиликатных микросфер на качество концентрата. Рекомендованы оптимальные технологические режимы флотации летучей золы с целью получения продуктов, пригодных для дальнейшего использования.
Ключевые слова: зола уноса, флотация, собиратель, вспениватель, недожог угля, алюмосиликатные микросферы.

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PROCESSING OF FLY ASH OF THERMAL POWER PLANT

The article deals with an investigation of possibility of underburning coal extraction from fly ash of Starobeshevskaya TPP by flotation method. The influence of aluminosilicate microspheres on the concentrate quality was observed. Different consumptions of reagent were compared. Optimal operating conditions of fly ash flotation were recommended to receive good products for recycling.
Key words: fly ash, flotation, collector, frother, underburning coal, aluminosilicate microspheres.

Coal plays a vital role in the world's primary energy mix, providing about 39 % of the world's electricity. About half of Ukraine electricity supply is generated using coal-fired thermal power plants (TPP). Coal-fired power plants produce millions tons of dangerous ash and other solid wastes. Two forms of waste are generated by combustion of burning coal: fritted (vitrified) slag and fly ash. Particulate matter considered as a source of air pollution constitutes fly ash. One of the most precious of fly ash constituent is aluminosilicate hollow microspheres with singular combination of properties such as a low gravity, high mechanical strength, thermal stability and chemical inertness [1–3]. Operating technologies make it possible to recover unburned carbon and ferrous particles and obtain aluminosilicate product from fly ash collecting by electrostatic precipitators. Processing involve regrinding of waste, hydraulic classification, magnetic separation, flotation, finishing on centrifugal concentrator and table [4–5].

Investigations focus on analysis of waste properties, development and testing of integrated processing technology that lets to recover metals and other components from waste and its utilization is important not only for saving metal resources, but also for protecting the environment.

Table 1

Size characteristic of fly ash

Sizing, mm	Yield, %	Ash content, %
+ 0,3	7,53	85,44
0,2 – 0,3	2,96	75,52
0,125 – 0,2	29,6	74,74
0,063 – 0,125	35,83	76,94
0,045 – 0,063	5,49	82,24
– 0,045	18,59	81,38
Total	100,00	78,00

Characteristic of fly ash of Starobeshevskaya TPP

Starobeshevskaya TPP burns anthracite chippings. The average ash of burning coal is 20–30 %. Content of ash collecting by electrostatic precipitators depend on type and nature of solid fuel. Analysis data demonstrated that filters collect fine dust (Table 1) especially by liquid dust control.

It is clear from the analysis results that all size fractions have underburning coal. The finer size of material there are the more odd-shaped particles in sample. Coal grains are dull, cindery, lightweight, breakable and porous, with very developed surface. Full unburned coal particles occur rarely, grains are bright with conchoidal fracture. The combustible content in fly ash is 19 – 20 % at an average.

Fly ash encloses significant quantity of glassy phase. Glassy fritted aggregates in sample are colorless, milky, yellowy and black, the majority is very lightweight spherical particles (Figure 1) with diameter 5 – 130 microns, at an average about 100 microns. Microspheres are often hollow and found foam on face of ash heaps and settling collectors.

Analyses of samples indicated that fly ash consists of two components – glassy particles and coaly particles. Composition of fly ash average sample is generally clinker aggregates and glassy matter (77 %), cindery coal particles are watched in the minority (22 %). Silicate cakes, thin covers of argillite, single grains of quartz and calcite are attended up to 1 %.

Research of fly ash floatability

The fly ash of Starobeshevskaya TPP was taken as investigated material for research of floatability. This material was floated without milling because particle sizes are corresponding to flotation process. Kerosene as collector and T-66 as frother were used in the flotation tests.

Series of froth flotation experiments were carried out to determine optimal consumptions of collector and frother. In view of unalike influence of non-polar and hetero-polar reagents on flotation of coal fines with different surface properties [6], consumptions of collector were taken from 1000 g/t to 3000 g/t, consumptions of frother — from 100 g/t to 300 g/t, feed pulp density was fixed 200 g/l. The dependences of froth product yield and ash content on different reagent consumptions were determined. The analysis results of flotation are represented in Figure 1.

Obtained results showed that collector dosages 1000-1500 g/t aren't sufficient for hydrophobization of all underburning coal particles, yield of concentrate is 13-15 % with ash content up to 26 %.

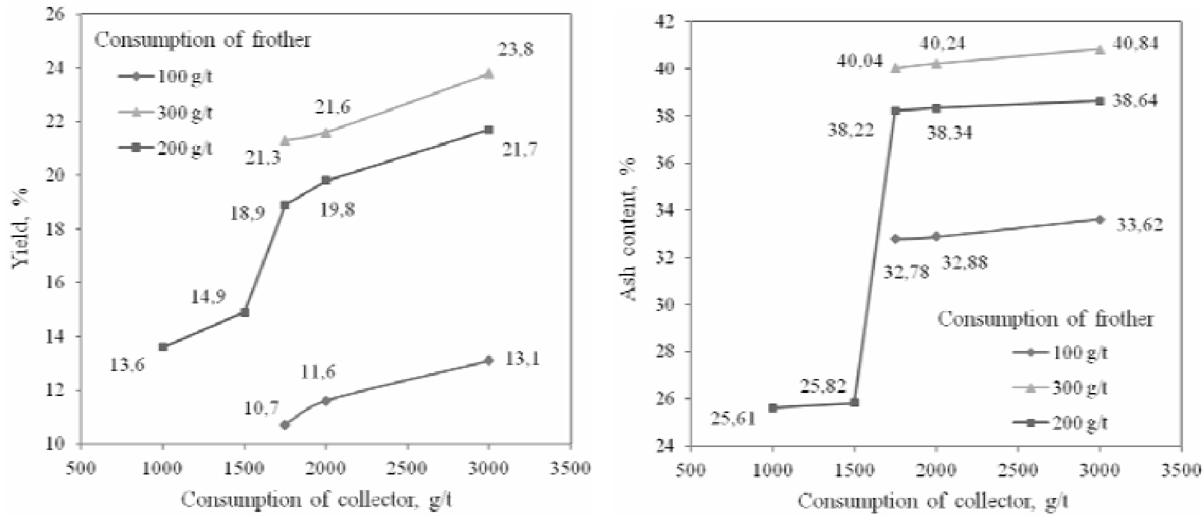

Fig. 1. Relation of the froth product characteristics and reagents consumption

Increasing of collector consumption to 1750-3000 g/t ensure additionally the floating of 5-8 % coal combustible with top ash content of froth product about 41 %. Ash content of tailings increases from 84.4 % to 86.4 % with variation of collector dosages from 1000 to 1750 g/t. Frother has meaningful influence on flotation results. Obviously, dosage of frother 100 g/t isn't enough for required frothiness to float good-covered coal particles by collector. These tests were determined that consumption of kerosene must be more than 1750 g/t and consumption of T-66 must be 200-300 g/t for flotation of fly ash.

Identical qualitative and quantitative characteristics of flotation products can be obtain with different variation of reagent consumption. There is connection between necessary to increase one of reagent dosage (e.g. collector) and to decrease dosage of other reagent (frother) and v.v.

When collector consumption is 2000–3000 g/t and frother consumption is 200–300 g/t, ash content of tailings is 87.0–88.5 %, ash content of froth product equals 38.3-40.8 %. This concentrate can recycle as additive to basic energy carrier in boiler furnaces.

Following series of flotation experiments were carried out to study of kinetic of different mineral aggregates extraction from fly ash. Tests were processed using kerosene (2000 g/t), T-66 (200 g/t). The concentrates were collected after 15, 30, 60, 90 and 120 s of flotation in separate trays. In this way the five frother products (f.p.) and tailings were obtain. Results of the fractional flotation (1) are stated in Table 2 and Figure 2.

Table 2

Summary of fractional flotation (1) results

Flotation time, s	Product	Yield, %	Ash content, %
15	f.p.1	5.8	46.6
30	f.p.2	3.9	30.7
60	f.p.3	3.0	35.9
90	f.p.4	2.5	40.2
120	f.p.5	2.2	45.0
	tailings	82.6	85.7
	total	100.0	77.8

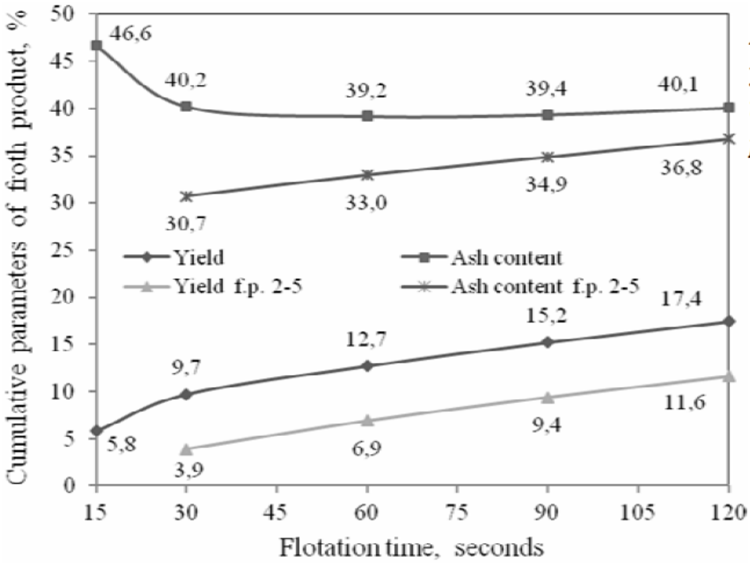

Fig. 2. Cumulative yield-time and ash-time profiles of froth products

Analysis of obtained products showed that frother product 1 consists of cindery coal particles (approximately 20 % from the product volume) and aluminosilicate microspheres (80 %). These microspheres have high ash and increase the ash content in frother product. Frother products 2 and 3 contain about 50 % cindery coal and 50 % glassy matters. Frother products 2 and 3 vary higher content of glassy fritted grains and lesser content of coal particles (20-28 %). Flotation tailings generally consist of glassy aggregates and single particles of quartz and slag.

Next experiments of fractional flotation were carried out to determine specific period while microspheres extract from slurry. The flotation was terminated after 60 seconds and frother products were drawn after every 5th seconds during initial 30 seconds and after every 10th seconds during rest 30 seconds. Results of the fractional flotation (2) are stated in Table 3 and Figure 3.

Table 3

Summary of fractional flotation (2) results

Flotation time, s	**5**	**10**	**15**	**20**	**25**	**30**	**40**	**50**	**60**	**tailings**	**total**
Product	f.p.1	f.p.2	f.p.3	f.p.4	f.p.5	f.p.6	f.p.7	f.p.8	f.p.9		
Yield,%	1.6	1.3	3.2	2.2	2.0	1.8	2.0	1.0	1.9	83.0	100.0
Ash content,%	88.1	75.4	17.0	23.6	28.9	36.2	38.3	42.7	45.6	85.4	77.6

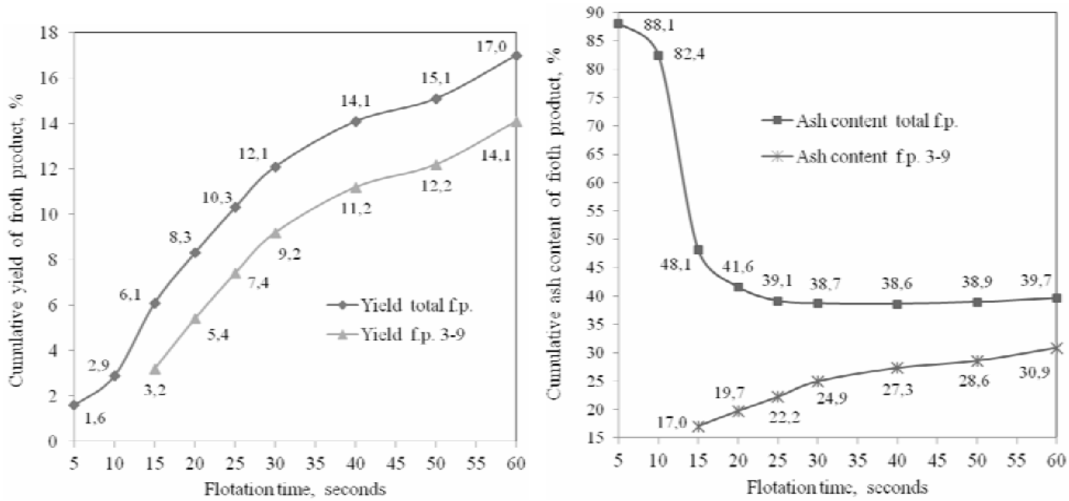

Fig. 3. Cumulative yield-time and ash-time profiles of froth products

Table 4

Summary of fractional flotation (3) results

Flotation time, s	**5**	**10**	**15**	**20**	**25**	**30**	**40**	**50**	**60**	**tailings**	**total**
Product	f.p.1	f.p.2	f.p.3	f.p.4	f.p.5	f.p.6	f.p.7	f.p.8	f.p.9		
Yield, %	1.1	0.9	5.3	2.6	2.1	2.0	3.0	1.5	0.9	80.6	100.0
Ash content,%	96.7	94.5	17.5	25.4	32.5	36.5	38.8	43.1	46.2	87.1	77.3

These tested data demonstrated that microspheres almost fully get into frother products 1 and 2 in 10-seconds initial period of flotation. Thus the concentrate obtained during next fifty seconds (without f.p. 1–2) has considerably less ash content (30.9 %) as compared with total frother product (39.7 %). Therefore microspheres must be separate from feed before the flotation process.

Aluminosilicate microspheres float through light density and don't require availability of air bubbles in pulp. In that case the dosage of frother in conditioning stage is not rational.

Series of flotation experiments were processed to determine the rational distribution of flotation reagents into cells. In these tests collector and frother add in portions – 20 % collector was fed into conditioning tank, the rest of reagents were fed in flotation cell after 10th and 30th seconds of process. Received results of the fractional flotation (3) are showed in Table 4 and Figure 5.

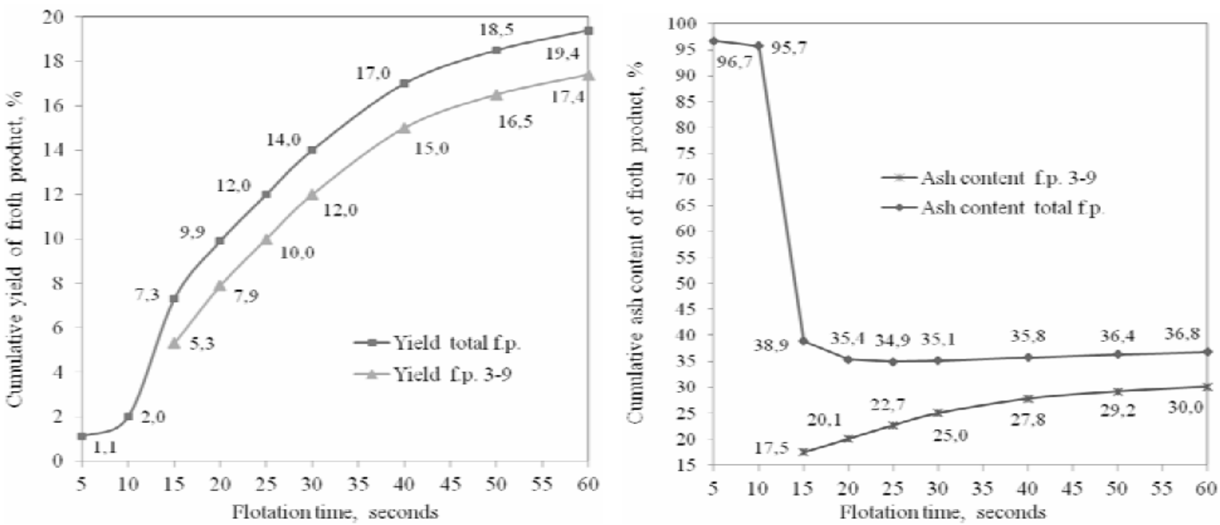

Fig. 4. Cumulative yield-time and ash-time profiles of froth products

It is observed from ash-time profiles (see Fig. 4) products 1-2 have high ash content. Underburned coal grains don't float together microspheres in foam owing to poor pulp aeration and poor hydrophobization of surface coal particles at the beginning of the performance.

If reagents are added after 10th seconds it is possible to recover «clean» concentrate, product yield increased as compared with preceding tests (Fig. 4) without rising of ash content. As profiles (see Fig. 5) indicate, such operating conditions with separate dosage of reagents are better for fly ash flotation.

Conclusion

1. For underburning coal extraction from fly ash of Starobeshevskaya TPP one-stage flotation is recommended. The consumption of non-polar reagent-collector (kerosene) should be 2000-3000 g/t and reagent-frother (T-66) 200-300 g/t.

2. It is also recommended to dispense flotation reagents in parts: 1st – 20 % collector into conditioning tank; 2nd – 80 % collector and 100 % frother into second or/and third cell of flotation machine. In the result it's possibly to receive 17.4 % concentrate with ash content 30.0 % for burning in boiler furnaces of power plants.

3. It is necessary to separate aluminosilicate microspheres from flotation feed for further industrial use.

The following investigations can direct on verification floatability of fly ash applying a new range of flotation agents, reprocessing of flotation tailings for extraction magnetic and other mineral impurities and processing for removal of aluminosilicate microspheres.

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