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Separation of minerals in a centrifugal field using circulating concentration

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Abstract. Due to the high speed of rotation of the centrifugal separator cone, it is possible to separate particles of small sizes. In its turn, the high speed of rotation of the centrifugal separator cone leads to clogging of the grooves of the separator cone with solid particles. The increased pressure of the turbulizing agent contributes to the loosening of solid particles in the grooves of the centrifugal separator cone, but can wash out particles with increased density from the grooves. Also, the loss of a valuable component is associated with the fact that particles of a valuable component located on the surface of the near-wall layer do not have time to get into the grooves in one cycle and are washed out of the separator cone together with the light fraction. In this regard, there is a need to study the increase in centrifugal separation using it in the circulating concentration scheme. Experiments were carried out in laboratory conditions on an artificial mixture of tungsten and quartz. The results of the experiments show an increase in enrichment rates.

One of the most famous methods of enrichment are gravity methods based on the difference in the density of separated minerals [1]. Gravitational methods are used to extract gold, based on the separation in suspended, pulsating, rectilinear or swirling and centrifugal pulp flows: enrichment at sluices, screw separators and concentration tables; enrichment on jigging machines; enrichment in hydrocyclones and centrifugal separators [2–7].

The prevalence of gravitational methods of mineral processing is explained by their advantages in comparison with other methods of mineral raw materials processing. The advantages of gravitational methods include their simplicity, environmental friendliness, allocation of minerals without changing their properties, wide range of fineness of the separated mineral particles [8].

At present, a significant part of the metal in placers is represented by fine and fine-grained gold, and in manmade deposits mainly fine-grained gold is located [9]. Centrifugal separators are a promising way to increase the extraction of fine particles of precious metals from loose ores and tailings [10]. Due to the high speed of rotation of the centrifugal separator cone, it is possible to separate particles of small sizes [11]. In its turn, the high speed of rotation of the centrifugal separator cone leads to clogging of the grooves of the separator cone with solid particles. The increased pressure of the turbulizing agent contributes to the loosening of solid particles in the grooves of the centrifugal separator

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cone, but can wash out particles with increased density from the grooves. Also, the loss of a valuable component is associated with the fact that particles of a valuable component located on the surface of the near-wall layer do not have time to get into the grooves in one cycle and are washed out of the separator cone together with the light fraction [12].

In this regard, there is a demand for studying the increase in technological indicators of centrifugal separation using it in the circulation concentration scheme.

To increase the performance of centrifugal separation, experiments were carried out with repeated passage of the material through a centrifugal separator, by circulation of the light fraction. The experiments were carried out in laboratory conditions on an artificial mixture of quartz, fineness - 0.5 + 0.02 mm, and tungsten fineness −0.04 + 0.02 mm. A mixture was prepared preliminarily with a total mass of 2000 g with a mass fraction of tungsten of 1%. The initial feed to the centrifugal separator was supplied in the form of a pulp with a mass fraction of solid βsolid = 30%.

Dispersed tungsten was used in experiments as an analogue of gold placer, due to its high density, and as the easiest to obtain analyzes of the final products.

In the work process, with multiple passage of material through a centrifugal separator, the pulp is liquefied with turbulizing water. To prevent flooding, the light fraction undergoes hydrocyclone. The hydrocyclone sands by gravity enter the centrifugal separator, and the discharge is fed into the turbulator of the centrifugal separator and used as a turbulizing agent.

The experiments were performed as follows.

A portion of the source feed undergoes hydrocyclone to produce sand and discharge. Sands are directed to centrifugal separation, and discharge - to turbulization of the near-wall layer in the cone of the centrifugal separator. In the process of centrifugal separation, heavy and light fractions are formed. The light fraction is returned to the centrifugal separation for a predetermined time to capture particles of increased density, after which it is removed to the tailings. In this case, particles of increased density are accumulated in the heavy fraction of centrifugal separation [13].

After processing the portion, the heavy fraction is unloaded from the grooves of the centrifugal separation cone using wash water.

The machines flow sheet of the experiments is shown in Figure 1.

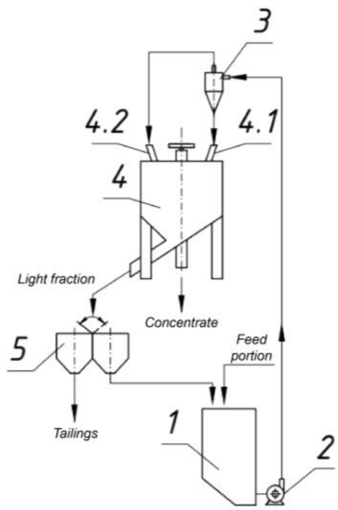

Fig. 1. The machines flow sheet for the experiments: 1 - sump, 2 - pump, 3 - hydrocyclone, 4 - centrifugal separator, 5 - flow switch.

The initial feed in the form of pulp is supplied to the sump 1, from which it is supplied by pump 2 to the hydrocyclone 3 for hydrocycloning. The sands of the hydrocyclone 3 are sent to the source feed pipe 4.1, and the discharge to the turbulator 4.2 of the centrifugal separator 4, in which centrifugal separation is carried out to obtain a heavy fraction in the grooves of the cone and light fraction, which is sent through the flow divider 5 to the sump 1 and pumped by pump 2 to the hydrocyclone 3, from which in the form of sand and drain returns to the centrifugal separator 4. Upon expiration of the set circulation time of the light fraction, using the flow switch 5, the light fraction is sent to the tailings.

Particles of increased density, which did not have time to get into the grooves of the cone, are carried out to the light fraction, which is returned to the centrifugal separator and trapped in the grooves of the centrifugal separator during circulation. The circulation is carried out over a period of time at which maximum extraction of particles of increased density is ensured into the grooves of the cone. The duration of circulation in each case is determined experimentally.

At the end of the experiment, the yield of concentrate and tailings, the mass fraction of tungsten in them were determined, and the extraction of tungsten in the concentrate was calculated.

After mathematical processing, the experimental data are presented in table 1.

Table 1. Modes and results of experiments on turbulization centrifugal separation of an artificial mixture of tungsten and quartz.

Experiment number	Cycles quantity	Rotation, r/min	Pressure, MPa	γ w, %	β w, %	ε w, %
1	1	1100	0.10	23.19	3.86	89.58
2	2	1100	0.10	23.77	3.93	93.47
3	4	1100	0.10	23.01	4.25	97.74
4	6	1100	0.10	22.99	4.25	97.22

The data obtained characterize an increase in the extraction of a valuable component with an increase in the duration of circulation of the light fraction. After four cycles, the indicators of the mass fraction and extraction of tungsten in the concentrate are aligned, which indicates an inappropriate continuation of the increase in circulation cycles.

The experimental results show the efficiency of centrifugal separation in the circulation mode of the light fraction. It allows to increase the extraction of particles of high density into the heavy fraction, as well as to improve the quality of the heavy fraction.

References

1. Meng Zhou, Ozan Kökkılıç, Raymond Langlois, Kristian E. Waters, Minerals Engineering, **91**, 42 (2016)
2. Yu. P. Morozov, *Theoretical justification and development of new methods and apparatus for the extraction of fine noble metals from ores of technogenic raw materials*, 397 (2001)
3. A. G. Lopatin, *Centrifugal dressing of ores and sand*, 222 (1987)
4. S. I. Polkin, *Dressing of ores and placers of rare and precious metals*, 428 (1987)
5. V. I. Zelenov, A. N. Shchendrigin, *Ways to improve the processing technology of gold and silver ores*, 40 (1986)
6. B. V. Kizevalter, *The theoretical foundations of gravity dressing processes*, 295 (1987)

7. V. K. Bagazeyev, News of Higher Educational Institutions. Mining Journal, **6**, 122 (1994)
8. P. M. Penkov, *Scientific and Technical Conference "Innovative Technologies for the Enrichment of Mineral and Technogenic Raw Materials"*, 184 (2017)
9. N. F. Usmanova, V. I. Bragin, Mining Information and Analytical Bulletin, **5**, 389 (2007)
10. Yu. P. Morozov, E. A. Falei, I. Kh. Khamidulin, News of Higher Educational Institutions. Mining Journal, **5**, 58 (2015)
11. M. R. Fatahi, A. Farzanegan, Advanced Powder Technology, **28**, 1443 (2017)
12. P. M. Penkov, *Scientific principles and practice of processing ores and industrial raw materials: Proceedings of XXIII International Scientific and Technological Conference*, 283 (2018)
13. Yu. P. Morozov, V. Z. Kozin, P. M. Penkov, Patent No. 2690590 (RF). The centrifugal separation method, Decl. 08.09.2018 - No. 2018129278/03 - Publ. on 08.09.2018