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Research Article

# EXTRACTION OF RARE METALS FROM MINING DUMPS IN BUBBLING EXTRACTORS

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## ABSTRACT

The article investigates the liquid extraction of valuable and rare metals from dumps of mining and metallurgical plants in an extractor with an increased contact time. The design, and the principle of operation of a bubbler extractor with an increased contact time based on pneumatic mixing are studied. The hydrodynamic parameters of continuous extraction without loss of valuable metals in the apparatus are studied.

## KEYWORDS

Bubbling, continuous operation, liquid extraction, rare metals, increased contact time, energy consumption.

## INTRODUCTION

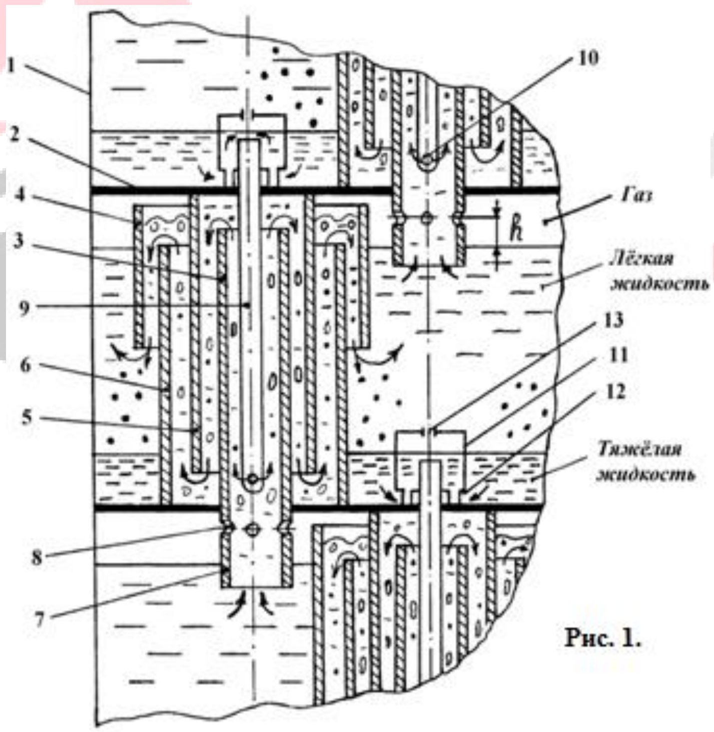
When extracting heavy, rare, trace and noble metals by hydrometallurgy methods, the fundamental criteria for choosing the type of extraction apparatus are low specific energy consumption for the extraction process, as well as providing it with the required contact time of the reacting liquids for the process [1]. Liquid extractors with pneumatic agitation or bubbling extractors fully meet these requirements. In terms of specific energy costs for the extraction process, such devices consume up to 3.5–4.0 less electrical energy compared to extractors in which liquids are mixed using various agitators [2,3].

The second condition for ensuring a sufficiently long contact time of the reacting liquids for the most complete extraction of the target component, from our point of view, is fully met by the design of a multistage bubbling extractor developed by us with an increased phase contact time [4].

The device and principle of operation of a multi-stage bubbling extractor is shown in fig. one.

## THE MAIN PART

The multi-stage bubbling extractor includes a vertical housing 1, divided by partitions 2 into separate settling sections. On the partitions between the inner 3 and outer 4 nozzles of the mixing device are additional inner (odd) 5 and outer (even) 6 concentric nozzles. The inner branch pipe 5 is fixed in the web of the upper partition of the settling tank section and is located with a gap to the lower partition of the settling tank section. The outer branch pipe 6 is fixed in the web of the lower partition of the sump section and is located with a gap to the upper partition of the sump section. In the lower part of the inner pipe 3 of the mixing device, there is a gas distribution nozzle 7 with holes 8 in the sidewall. Overflow tubes 9 for heavy liquids are also attached to the partition wall 2,




**Fif. 1. Multi-stage bubble extractor**

The extractor works as follows. Light liquid through the lower section of the gas distribution nozzle 7 enters the inside of pipe 3. Therethrough the holes 10 of the overflow tubes 9, heavy liquid flows from the settling part of the overlying settling section. With the

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joint movement of a mixture of liquids from bottom to top inside nozzle 3, then from top to bottom between nozzles 3 and 5, then from bottom to top between nozzles 5 and 6, and finally, from top to bottom between nozzles 4 and 6, the liquids are intensively mixed by bubbling inert gas that enters nozzle 3 through holes 8 of gas distribution nozzles 7. In the upper part of the space between nozzles 5 and 6, gas bubbles are separated from the mixture of liquids and the gas enters the gap between the upper partition of the settling tank section and the uppercut of the pipe 4, from where it enters the mixing devices of the overlying settling section. The mixture of liquids exits between nozzles 4 and 6 into the settling part of the settling section,

Overlapping the upper sections of the overflow tubes 9 with caps 11 with slots 12 in the lower part ensures that only completely settled heavy liquid enters the tubes 9. Holes 13 are used to release air from the caps 11 when filling the extractor with liquids before starting.

By installing any even number of additional concentric pipes between nozzles 3 and 4, each odd of which, starting from the innermost one, is installed with a gap to the lower partition of the section, and each even number - with a gap to the upper partition of the section, it is possible to provide any necessary contact time of the reacting liquids.

The normal operation of the extractor will be ensured when the annular channels between nozzles 3 and 5, as well as 4 and 6, will have such a cross-section at which the velocity of the mixture of liquids there will be a greater rate of ascent of gas bubbles in a mixture of liquids.

Experiments to establish the main hydrodynamic parameters of the apparatus, as well as the efficiency of mass transfer processes, were carried out by us in a laboratory setup, the scheme of which is shown in fig. 2.

The mixing zones of the extractor model glass shells 4, 14 and 15, through which it is possible to visually observe the processes occurring in them (crushing of drops of the dispersed phase, the behaviour of air bubbles for mixing, etc. The light phase, the flow rate of which is controlled by the rotameter 7 and valve 6, is fed into the apparatus from the LF tank using pump 2, and the heavy phase, the flow rate of which is regulated by rotameter 15 and valve 13, comes from the TF tank through holes in the lower end of tube 10. When the phases move together from bottom to top inside shell 4, from top to bottom inside shell 14 and from bottom to top inside the shell 15, the liquids are intensively mixed by the inert gas supplied from the blower 28, and the flow rate of which is regulated by the rotameter 9 and the valve 8. The mixture of liquids after the apparatus is collected in the TF tank. The mixture of liquids is separated into light and heavy phases in tank 31, in which inert gas is also separated from liquids, which are removed from the installation through pipe 16.

To determine the true size of the dispersed phase droplets and gas bubbles, a camera 22 is used, and the level of liquids stratifying in tank 31 is controlled using a level gauge 17 to control the flow of heavy liquid into the tank 30 by valve 29.

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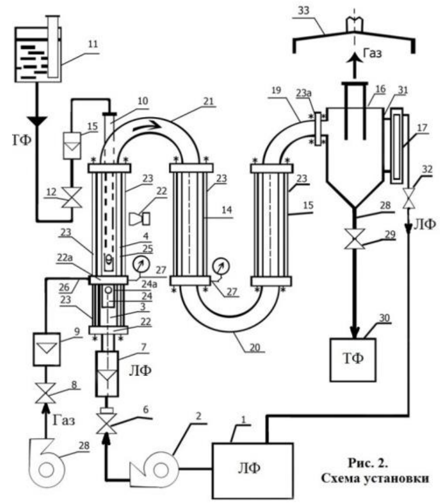


**Fig. 2. The main hydrodynamic indicators of the device**

On this installation, experiments were carried out to determine many of the hydrodynamic parameters of a multi-stage bubbling extractor. The rate of outflow of a heavy liquid into a mixture of liquids and gas through the holes of the tube can be calculated using the following equation[5]:

$$\omega_T = \sqrt{\frac{2g^2 \cdot h[\rho_T - \rho_{см}(1-\varphi)]}{\xi}} \quad , \qquad (1)$$

where $\rho_{cm}$ - density of the mixture of light and heavy liquids, kg/m3;

$\varphi$ - volumetric gas content;

$\rho_T$ - density of heavy liquid, kg/m3;

$\xi$ - coefficient of resistance of the hole in the tube 10.

Since for a specific liquid system, all quantities included in (1) will be constant, except for $\varphi$, then the performance of the extractor for a heavy liquid depends precisely on the gas content $\varphi$.

With the co-current motion of liquid and inert gas, the volumetric gas content is determined from the dependence [6]:

$\varphi_{пар} = (1 - 0{,}04\omega_ж) \cdot \varphi^1$, (2)

and with countercurrent movement of liquid and inert gas, the volumetric gas content can be determined from the dependence:

ωg against = (1 + 0.04ωl ) φ1 , (3)

where ωl is the reduced fluid velocity, m/s;

*φ1* is the gas content in a stationary liquid.

To calculate φ1, it is proposed empirical equation:

φ1 = 2.47 ωg0.97 , (4)

where *ωg* -reduced gas velocity in the mixing zone, m/s.

## CONCLUSION

The mixing of immiscible liquids was carried out in a zigzag mixing zone. This will increase the time of intensive mixing and increase the efficiency of the extraction process. Volumetric parameters of gas in the mixing zone of the extractor ▯, are important for the design of the apparatus, therefore, the dimensions of the zones of the apparatus are determined depending on them. As a result of the scientific research carried out, equations were derived for determining the gas content and velocity in the mixing zone in the newly created apparatus.

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