Multisectional Technology of Waste Waters Purification

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ABSTRACT

Mining waste waters requires a wide range of purification techniques depending on the degree of contamination as well as the chemical nature of the contaminants. The three-step purification technology relating to fine colloids as well as oil refining chemicals and by-products has been carried out. The idea of the new technology is based upon the multisectional principle. Different sections are supposed to be combined depending on the purification requirements.

The proposed technology includes three consecutive steps as follows:

(i) coarse separation;
(ii) separation of oil processing products and fine colloids;
(iii) sorbtion purification to allow contamination limits.

Bench studies have been carried out to show the advantages of the new technology. The first stage of purification was realised using a hydrocyclone fine-layer refiner; the second stage an implied pressure flotator and/or electric flotator; the third stage was based on a sorbtion column.

Multisectional technology proved to have several benefits as compared to traditional methods applied in the mining industry. The main advantages of this technology are as follows: low energy and time consumption; compact arrangement of the main units; cheap service and easy maintenance; wide range of purification degrees; high concentrations of oil processing materials ready for immediate utilization after water purification.

The possible areas of application include transport, oil refining and processing, the food industry, the chemical industry and pharmacology.

INTRODUCTION

The technology of storm and industrial waste waters purification includes the following stages: mechanical separation of admixtures, physico-chemical purification, biochemical decomposition of admixtures. Operation parameters and a purification flow chart are chosen depending on the composition of contaminated water and the requirements of the purification specification.

Mechanical purification

The first stage is realised by using sandtraps, a sediment plates tank, hydrocyclones and fine-layer refiners. The original wavy type of sedimentary plates and the flows structure in fine-layer refiners intensifies the rate of suspensions precipitation and the rise of oil emulsion droplets. Mechanical purification allows the removal of 80 - 90% of suspended substances and 75 - 85% of oil processing materials.

At this stage, inspite of the hydrocyclones and sediment tanks high efficiency the further removal of dissolved processing materials and oil particles (less then 10 μm in size) by means of the gravitation method is practically impossible.

This is the reason for the flotation purification that removes fine-dispersed droplets and particles from such an aggregate-stable system as water purified in sediment tanks.

Flotation purification

Comparison of various flotation methods allows one to recommend the compressing flotation for the purification, aeration being realised by air ejection from the environment to the aspiring pipeline included in the centrifugal pump and its subsequent dissolution in the force pipeline and the saturator. Water saturated with air from the elevated tank is supplied to the flotation chamber by means of the reduction tap. That results in pressure decreasing until it becomes normal. The amount of air displaced from the over-saturated solution should be equal to 1 - 5% of treated water volume, thus ensuring the required flotation effect. The experiments have shown that the increasing of the throttling rate from 9,9 to 15 m/sec, the degree of water saturation with gas being constant, leads to an important rise in the purification efficiency. With the ejection method of water supplying to the purified water the gas liquid interface highly increases and the complete water saturation with gas takes only 1 - 2 minutes.

Column flotation

Extensive introduction of column flotation machines is accounted for by the following: high process performance; an opportunity for fines and coarse material benefication; simple process control; low power requirement; efficient flotation of highly loaded slurries which results in cell volume and reagents dosage reduction; no moving parts; low floor space requirement; simple design. One of the advantages is the possibility of creating various aerohydrodynamic conditions in a single machine. Low intensity of slurry agitation results in high selectivity of slurries flotation due to considerable reduction of particle entrainment and lower dispersion of material fractions retention time distribution. High efficiency of column flotation allows for decreased flotation times, reducing the number of cleaner stages and the circulating load in the circuit which raises stability and reliability of the operation.

All the columns machines developed and produced by western companies and in Russia are monocells with the same aerohydrodynamics throughout the cell. Such designs allow for optimum recovery of a particular size fraction but certainly not the whole range, thus the efficiency of other size fraction recoveries will be low.

For treating flotation feed with a considerable amount of coarse material not requiring regrinding for mineral liberation a machine was designed combining the processes of froth separation and column flotation. It is expedient to size the feed in a hydrocyclone prior to flotation. Then coarse material (sands of the hydrocyclone) is fed to the froth layer of the froth separation cell. Hydrocyclone overflow enters the first counter-current section of the column, tailings of the froth separation cell are also fed into that section. Tests of a pilot machine for coal slurry flotation showed the possibility of considerable reduction of coarse fraction losses with flotation tailings by 30 - 40% and increase of concentrate yield and grade.

Column flotation intensification

The distribution rate of bubbles being formed with different structure air spargers used in column machines have been examined, the results obtained have shown that more thorough air sparging could be obtained by using pneumohydraulic aerators under the air pressure equal to 3 - 4 atm. However, when the above-mentioned conditions are used, the size range of bubbles obtained is in the range between 200 and 1200 μm, it is not sufficient for the recovery activation of fine particles less than 40 μm.

The direction of flotation process intensification, without taking into account the types of machines, is to be connected with obtaining the bimodal range of bubble size distribution. It is necessary that the left part mode of function distribution be in the range between 40 and 50 μm. Input of bubbles of such size improved performance of the flotation process by means of coalescence where the microbubbles themselves are used as activators.

The flotation process can be divided into the following steps: preparation of particle - microbubble aggregate, coalescence of microbubbles with coarse (transport) bubbles, mass transfer of a flotation complex to the froth layer.

The main task of the flotation process intensification is the choice of more effective and economically available method of obtaining the microbubbles.

At present there exists the compression method and the electrochemical one. The latter is more effective. The electrochemical method allows the partial use of the compression mechanism by water over-saturation with dissolved electrolytic gas without creating the super-atmospheric pressure.

On the basis of special studies a diaphragm bipolar electrolyzer has been chosen. Catolyte and anolyte are supplied to different points of the process - catolyte and anolyte being the resultant products of such constructional concept - allowing control over the selectivity of the process.

Stainless steel is the preferred material of construction because of its chemical stability, durability under anode polarization conditional and a small value of over-voltage resulting in hydrogen and oxygen production. Tarpaulin and filter cloth have been used for the diaphragm.

During the experimental run the electrolyzer appeared to have the following advantages: high performance, economical and a simple way of manufacturing it.

The electrolysis of technological water resulted in obtaining two products: anolyte - which had oxidising properties and catolyte - which had reducing properties.

Taking into account the relationship between pH changes and redox-potential, dissolved oxygen concentrations were determined relative to the electrical energy consumption N and electricity quantity q. One might control the physico-chemical parameters of the flotation process without reagents. The technological effectiveness of the flotation process has great importance for solving ecological problems. One must check the physico-chemical parameters of electrolysis product for each case.

When tested the products stability after electro-chemical water treatment, it was found that anolyte was much more stable than catolyte. It is necessary that the catolyte be used at once after its production. Anolyte is stable for some hours.

Electrolytical gas bubbles dimensions were determined by films taken by micro-photography. Hydrogen bubble diameter varies in the range between 35 and 70 μm, with oxygen bubble diameters between 100 - 120 μm.

Electrolytic gas bubbles are much more soluble than the coarser ones. If formed by electrolysis the bubbles less than 30 μm are in non-equilibrium and the solution can be over-saturated by electrolytic gases. The over-saturation dependence of electrolytic gases dissolved in water depends on bubble radius and is calculated according to the Kelvin equation.

$$Cr / Cb = \exp\left[\frac{2tV}{2TRr}\right] \tag{1}$$

where

Cr - equilibrium concentration of gas dissolved in water relative to the bubble;
Cb - equilibrium concentration of gas dissolved in water when gas/liquid interface is flat;
t - surface tension of gas/liquid interface;
v - molecular volume of gas;
R - universal gas constant;
T - temperature;
r - bubble radius.

The bubbles are formed on fine particles surface from over-saturated solution after supplying catolyte and anolyte to technology process. In such case the compression mechanism takes place.

A number of studies having been finished, an electrolyzer for column flotation was manufactured for industrial investigations.

Electrolyzer specification is as follows: rate flow is 10 l/min, distance between electrodes is 10 mm, surface density of current is in the range betwen 16 and 20 A/sq.m, volumetric density is within 0.1 - 0.5 A/l.

The column machine was installed for the cleaner cycle of technology process. Catolyte was being supplied to the column machine feed. Anolyte was being supplied to scavenger flotation feed.

Rougher and scavenger flotation stages were equipped with mechanical type machine. As a result improved recovery of concentrate was achieved. Increase of recovery was due to fine sizes being collected by the electrolytic gases.

If any ores contain fine size classes expedient to the use of the investigated method of column flotation process intensification with help of electrolytic gases can be considered.

Sorbtion purification

The next stage of purification takes place in the sorbtion pressure filter and allows to reduce oil processing materials concentration to 0,1 mg or less per litre. As a sorbent, ceramzit, activated coal, ceolit or peat briquettes are used. The great advantage of a sorbtion filter is the possibility of regeneration and sorbent re-using.

To define optimum methods and purification conditions the installation including various equipment has been mounted. Research carried out has allowed us to develop a model installation and to define the optimum technological conditions of waste waters purification. If necessary an ozonizer and membrane filters can be added to it.

The experience of this installation exploitation at some Russian plants and automobile enterprises has revealed its advantages: high efficiency of methods used; low costs and energy consumption; compactness; easy assembling and maintenance, flexible technology and high purification efficiency.

CONCLUSIONS

Purification of mining waste waters is one of the most important ecological problems. Mining waters are polluted with suspended substances (100 - 150 mg/l), ions of iron (70 - 200 mg/l), aluminium (up to 30 mg/l), copper, zinc and other metals (up to 1%). Acid mining waters have pH 2,9 - 3,5. We have developed purification technology of acid waste water after its neutralization with lime milk. It combines column and compressing flotation with the use, as a collector, of one of the fractions of alfa-remitide monocarboxilic acids. A reagent is supplied to the flocculating chamber where ferric and aluminium hydroxide precipitates become larger and enter the column machine. Clarified water containing 20 - 30 mg/l of suspended substances is ejected into a water body or is used for technical needs. After dewatering on a vacuum filter and drying the froth product is used as a cement ingredient. This technology has been tested and is being designed for the purification of mining waste waters at "Shumihinskaya" mine under "Kizelugol" industrial amalgamation. The use of the flotation method of purification instead of the gravitation one allows reduction of the costs of water purification and sediment compression processes 2 times, the volume of purification facilities - 50 times, investments - 10 times. The technology developed can be used for waste waters purification at automobile plants.

The example of sewage water from Balhashsky integrated work shows the expediency of purification process realisation in column flotation machines. The degree of purification satisfies the requirements to the waste waters utilisation. Residual content of copper and zinc does not exceed 1,2 and 0,5 mg/l, original content being 21,2 and 35,0 mg/l respectively.