VIBRATORY COLUMN FLOTATION MACHINE – VIBRATORY – ACOUSTIC AND TECHNOLOGICAL RESEARCHES

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ABSTRACT

A laboratory model of column flotation machine with height 2000 mm and diameter 50 mm with vibratory – acoustic powder disperser of gas phase is presented. A module principle, which gives an opportunity for determination an optimum height of the supply device is used, regulation without rate at the level of pulp and precisely determination of the necessary quantity of additional water which is need for irrigation of the foam layer. Research of effect of frequency and amplitude of vibrations on precipitation of mineral granules with different density are done.

Key words:column flotation, vibratory – acoustic powder disperser of gas phase

INTRODUCTION

The flotation technique and technology developments are closely connected with the improvement of the flotation machines design. The main road solving the task for flotation process intensification is the creation of high – productive flotation machines.

The contemporary requirements in the field of pulp aeration and bubble mineralization theories impose the design of pneumatic flotation machines of column type that find application at the flotation of ores of non-ferous, noble, rare and ferrous metals, coal and other mineral resources as well as wide use at purification of waste water from different productions. (Черных, 1996)

The column flotation machine wide practical introduction appears to be an important achievement during the last decade in the field of flotation concentration. The advantages of the column flotation machine in comparison with the mechanical and pneumomechanical are the following: increased productivity improved hydrodynamics, of concentrate with the required quality at minimal quantity purifying and control operations, production area decrease and economy of electric power.

The movement nature of the particle and the bubble is an important factor, which determines the probability of flotation complex formation, mineralization rate, flotation speed and the process power consumption. (Черных, 1996) The inertial forces which destroy the particle – bubbles complex in column are insignificant. This is connected with the absence of a stirring device and the pulp flow low turbulence.

The increase of the air bubbles flotation activity is connected with the increase of their conditioning time, i.e. the interval between the formation moment and the bubble mineralization. In consequence of the column considerable height the sojourn duration of the air bubbles in it is not longer than 20s, i.e. a mineralization process at optimal flotation activity of the bubbles is realized. (Рубинщайн, 1989).

Here should be mentioned the increased flotation selectivity in he column devices due to acceleration of the processes of the secondary concentration, which is going in the purification zone of the froth layer, where fresh water is supplied. This affords an opportunity for high-quality concentrates obtaining and simplifies the technological scheme.

The basic research field in column devices is the fine-grained pulp flotation. The absence of intensive pulp mixing, product purification zone, high position of the feeding level, and the thick froth layer contribute to the obtaining of concentrate of better quality in comparison with the impellers. .(Рубинщайн, 1989).

There is a bigger probability of capture and withstanding of the coarse particle to the bubble so in some cases the column flotation machine use could turn out to be expedient for coarse – grained material flotation, as well. (Foot, 1986)

The flotation machines work effectiveness depends on the conditions of the air dispersion. The aerators must provide a maximum gas content at an optimal average massiveness of the bubbles. The following claims are demanded to the aerators: providing for such a bubbles size that assures the flotation complex emerging, minimal pulp macrocirculation in the chamber, stable aeration characteristic.

The aerators designs developed in accordance with the requirements could be combined by the action principle as follows: pneumatic, hydraulic (swift – flowing) and pneumohydraulic.

The perforated pipes or plates through which the compressed air passes are assigned to the most widespread pneumatic aerators. Textile aerators are also used at the column flotation machine. Their advantages are the low price and restoration after concentration while the unsteady aeration, the coarse bubbles (up to 3 mm) appearance and the possibility of liquid fall into the airway are considered to be disadvantages. (Finch, 1990) The textile aerators are in shape of disk frame, jacket, perforated pipes, lattice, etc. Aerators differently shaped as air distributive lattices are used as well.

Aerators made from Teflon, porous and metal ceramics are out of use because of the great value, holes blocking by particles and complicated regeneration. (Рубинщайн, 1989)



Figure 1. Vibratory column flotation machine – scheme of principle

The basic aerator type in the column flotation machine is the pipe device. An aerator representing a set of tightens in group hollow rings from porous (wool or porous polyethylene) or elastic (raw rubber) material is proposed for the aeration characteristics improvement. Changing the group tightening extent regulates the bubbles dispersive composition. The pulley aerator design is analogous. The ring pivot is vertically situated and the diameter increases from top to bottom. The diameter and the height of the pulley aerator ALL - 15 for air feeding up to 15 m³/h with compression of 0,15 MPa are respectively 14 cm and 13,5 cm. (Рубинщайн, 1989)

As a separate tendency the vibrating pneumatic flotation machines design should be mentioned. Their action principle is based on air dispersion by vibrations at its feeding to the aeration chamber. The pulp vibrating turbulent movement creation reinforces at the liquid flow through special lattices.

VIBRATORY COLUMN FLOTATION MACHINE

A laboratory model of a vibratory column flotation machine – 2000 mm in height with diameter 50 mm and gas phase vibrating disperser is developed at the laboratory of "Vibroacoustic Intensification of the Technological Processes" at the department of "Mineral Technologies" of the University of Mining and Geology "St. Ivan Rilski". It is realized on a modular principle, which provides a possibility for determination of the feeding device optimal height infinitely – variable regulation of the pulp level and precise determination of the necessary quantity of extra water for the froth layer irrigation. The vibratory column flotation machine basic elements are sensor (fig. 1-1), vibrator (fig. 1-2), air disperser (fig. 1-3), module for creation of single gas bubbles (fig. 1-4), feeding device (fig. 1-5), machine chamber (fig. 1-6).

The vibratory disperser provides the opportunity of certain technological parameters research: gas bubble size change, change of the gas bubbles emerging speed and solid phase sedimentation speed, the influence on the opportunity of mineral particles attachment to the air bubbles, purifying of the froth layer from rock particles.

The vibrator is electrodynamic type, power 40 W and a possibility of a wide range frequency and amplitude change, overlapping the supposed range of vibratory parameters, required by the research.

Two modifications of the air- dispersing unit were constructedfor vertical and horizontal vibrations. The air-dispersing unit for vertical vibrations (fig.2-1-air) disperses air by its transition through an annular slot, which allows rate regulation within certain range and production of gas bubbles of certain size by regulation of vibrations frequency and amplitude. Simultaneously, with the bubbles production, the vertical oscillations create a vibroacoustic field, which is distributed along the column height.

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Figure 2. The air-dispersing unit for vertical vibrations

The air-dispersing unit for horizontal vibrations (fig.3-1-air) produces gas bubbles through round holes, perpendicular to the direction of the vibratory field vector.



Figure 3. The air-dispersing unit for horizontal vibrations

The feeding modulus allows pulp supply into the flotation machine and even distribution of pulp along the column section as well as filling with water for vibroacoustic measurements.

The module for gas bubbles production provides the opportunity of air micrometric supply through changeable air nozzles of certain initial diameter. The pulp level is infinitely – variable regulated by the communicating vessels method. . Fig 4 shows the air disperser 1, apart of the machine chamber 2 and a vibrator 3. The chamber product is removed by a pipeline and valve 4 to the tank 5 for the coarse fraction and the fine fraction is collected in an extra vessel. The spillway movement in vertical direction provides the required pulp level in the column.



Figure 4. Vibratory column flotation machine – basic parts

THE VIBRATIONS INFLUENCE ON THE SOLID PHASE

Researches were carried out for the effect of frequency and amplitude of vibrations on speed of precipitation of mineral grains of different density. It was known that speed of precipitation decreases with the increase of intensity of oscillating, however the question of effect of diameter and relative weight of particles was still open. For that purpose a series of experiments were carried out with single mineral grains of a diameter from 0,09 to 0,155 and densities of different grains 2,65; 5,1 and 7,6 g/cm3. Frequency of oscillation changes from 20 to 70 Hz, and amplitude - from 1,5 to 3,0 mm. Average results of experiments were presented in tables 1. Experimental researches involved the conclusion that vibrating media provided additional force of resistance, applied to the mineral particle, which provoked decrease of the speed of falling down. This force is a function not only of frequency of applied vibrations - fig. 5, where experimental values showed decrease of speed depending on density of particles. It was visually observed that when the particle did not reduce significantly its speed /for certain vibration parameters/, its amplitude of oscillation is approximately equal to the amplitude of oscillation of the liquid. When speed of a particle reduces significantly its amplitude increases visibly.

This dependency between speed of falling down of mineral grains into a liquid vibrating medium and parameters of vibrating field may be explained as an interaction between two oscillation motions – motion of mineral grains and motion of applied vibrations.

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Table 1. Decrease of the speed of precipitation in dependence of density of particles

Frequency	Amplitude 2 mm, d=0.12 mm		
f [Hz]	Reduction of V [%] for density g/cm3		
	2.65	5.1	7.8
	%	%	%
20	1.54		
30	3.39	5.38	4.1
40	1.34	7.6	9.73
50	4.54	6.59	7.68
60	5.6	6	8.77
70	4.22	9.6	12.16

For lower frequencies of vibration reduction of speed is lower due to lower vibration speed. For particles of higher density reduction is higher due to higher speed, with which they meet the pulsing medium.



Figure 5. Decrease of speed of precipitation in dependence of frequency of vibrations and density of particles

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