Exploration on Mineral Flotation Bubble Velocity and Extraction Method of Size Distribution Feature

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Abstract. Mineral flotation is a complex physical and chemical process that involves solid, liquid and gas phase separation. Many operating variables influence the efficiency of the separation process, and the mutual coupling effects have decisive influence on flotation performance indicators, both from the macro level of physical factors such as solid particle transmission, as well as from the micro level of chemicals and fluid dynamics factors, etc.

Mechanism analysis of froth flotation

Mineral froth flotation was complex physical and chemical processdone in solid liquid gas system. The basic process includes add water into pulp to grind it to be pulp, add flotation reagents to be mixed by flotation machine, form bubbles of air import, hydrophobic mineral products adhesion on the bubble,mineral hydrophilic kept in water, and finally realize the separation of useful minerals.

Process of froth flotation

The mineral isnatural compounds or natural elemental produced by physical chemistry or biology effect in natural geological processes in the crust. Often, most of the ore developed from the earth’s crust or the sea, the useful mineral and gangue are closely linked together. If not the two separated, there is no physical method that can separate the useful minerals from the gangue. Theprocess to separate useful minerals from gangue is known as mineral processing. [1]The process consists of two basic steps, liberation and separation.

Two importantindex of the evaluation of mineral separation quality aregrade and recovery rate. Mineral grade G refers to the unit volume or weight of useful components or useful minerals content in the ore, usually expressed as a percentage by weight:

$$G=\frac{M_{valuable}}{M_{valuable+waste}}\times 100\% \qquad (1\text{-}1)$$

Grade of raw ore says the concentrate degree of raw are, while grade of fine ore says the concentrate degree of raw are reflects some sort of recycled content rich lean degree of elected to concentrate.

$$R=\frac{M_{valuableproduct}}{M_{valuableinput}}\times 100\% \qquad (1\text{-}2)$$

In the actual production process, the formula below is always used to calculate the recovery rate.

$$R=\frac{\beta\cdot(\alpha-\theta)}{(\beta-\theta)\cdot\alpha}\times 100\% \qquad (1\text{-}3)$$

1) Distribution mechanism of flotation process

The bigger of contact angle, the thinner the wetting layer so the greater the possibility that bubbles can stick on the mineral surface. [2]The spontaneous process of bubble adhesion depends the ore grain’s natural properties. When gas liquid solid enter equilibriumphase, the equilibrium equation is:

$$\gamma_{gassolid} = \gamma_{liquidsolid} + \gamma_{gasliquid} \cos\theta \tag{1-4}$$

When ore grain changes from contacting air bubbles to adhesion on the bubble, the free energy variation $\Delta\gamma$ on surfacecan be obtained by type (1-5) :

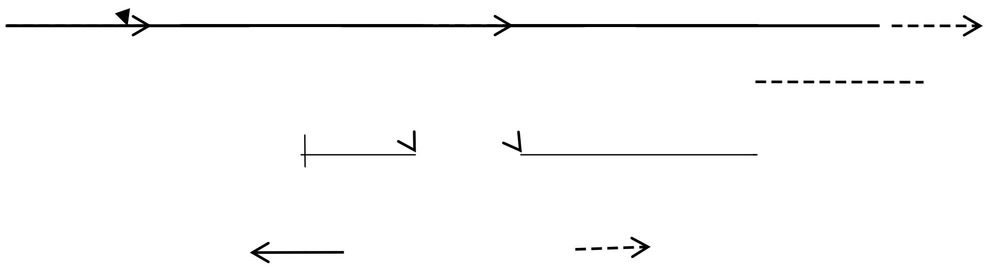
$$\Delta\gamma = \gamma_{gassolid} - (\gamma_{liquidsolid} + \gamma_{gasliquid}) \tag{1-5}$$

Take equilibrium equation into:

$$\Delta\gamma = \gamma_{gasliquid}(1 - \cos\theta) \tag{1-6}$$

2) Flotation equipment and flotation process

When the proposed hybrid solid minerals mixed in the water, the suspension liquidafter mixing income for is flotation pulp, then flotation are fed into the container. Flotation container mainly refers to flotation machine and other equipment that realize flotation technology. Usually, according to the mixing and aeration way, flotation equipment can be divided into mechanical agitation type flotation machine, inflatable flotation machine, flotation machine, etc.



Fugure 1. Flotation process flow diagram of some factory

Two-phase bubble and three-phase bubble

Foam produced in industrial flotation process are all the three-phase foam, whose English translation is froth. The bubble has three phase coexistence, including liquid, gas phase and solid phase. The solid phase formed by gas in a liquid dispersed bubble is called two-phase bubble, English terms is foam.[3]Foam is the basis of discussion of froth, so the understanding of the two phase foam formation and stability mechanism is very necessary.

Laplace algorithm model and surface flow of bubble motion in the foam

As a result of opacity and its own properties of froth, it is hard to tell the bubble velocity field and analyze bubble structure. In the actual production, experienced flotation operation workersestimate the surface layer of foam flotation effectaccording to the characteristics by looking at the surface of the foam layer.

Laplace model of bubble motion

Laplace equation model can describe the bubble motion in the mineral froth flotation accurately. Bubble movement two-dimensional dynamic model is put forward by Murphy. The model assumes that the bubble flow in line with the Laplace equation of motion. In two-dimensional two-phase bubble motion experiment, similarity of the model of air bubbles movement tracks and experimental bubble movement in the process is verified . On the trend of movement, the model fit reality bubble movement.

$$\nabla \cdot V = 0 \tag{2-1}$$

By fluid mechanics, for any small volume of fluid, motionat some point can be decomposed into translation, the instantaneous rotation and deformation. [4]On the basis of the concept of the decomposition speed, fluid motion can be divided into two categories, no rotary motion and rotation motion. The second assumption is that flow is irrotational conditions. Its physical meaning is the shear force within the bubbles in a fixed position is constant. Irrotational conditions are expressed as:

$$\nabla \times V = 0 \qquad (2\text{-}2)$$

Under Cartier coordinates, continuity equation has the following form:

$$\frac{\partial V_x}{\partial x} + \frac{\partial V_y}{\partial y} = 0 \qquad (2\text{-}3)$$

It is noticed that on the streamline the speed of each pointand streamline are tangent, so the streamline equation is:

$$\frac{dx}{dy} = \frac{V_x}{V_y} \qquad (2\text{-}4)$$

Combined with the formula (2-3) and (2-4) it is known that there is a function Ψ to satisfy the following relations:

$$V_x = \frac{\partial \psi}{\partial y} \qquad (2\text{-}5)$$

$$V_y = -\frac{\partial \psi}{\partial x} \qquad (2\text{-}6)$$

V_x is the horizontal velocity, V_y is the vertical speed, function class ψ is the stream function. Take it to a (2-3), Poisson equation is gotten as below:

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = \Omega \qquad (2\text{-}7)$$

When motion is irrotational, $\Omega = 0$, so

$$\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0 \qquad (2\text{-}8)$$

Numerical Laplace equation

in the simulation of the complex movement of air bubbles in foam includes air bubbles go from the slurry bubble to the surface of foam layer, and finally become foam productsfrom the overflow mouth deduction flotation cell.

1) Finite difference method

Finite difference method requires the grid system divided into discrete points, it is differential operandsin the grid approximation equation. All linear difference equation can be approached with finite difference method, combinewith different linear approximation through the finite difference method can also be used for solving some nonlinear difference equation. A typical central difference:

$$\frac{\partial^2 \psi}{\partial x^2} \approx \frac{\psi_{i-1,j} - 2\psi_{i,j} + \psi_{i+1,j}}{(\Lambda x)^2} \qquad (2\text{-}9)$$

$$\frac{\partial^2 \psi}{\partial y^2} \approx \frac{\psi_{i-1,j} - 2\psi_{i,j} + \psi_{i+1,j}}{(\Lambda y)^2} \qquad (2\text{-}10)$$

Laplace equation is:

$$\frac{\psi_{i,j+1} - 2\psi_{i,j} + \psi_{i,j-1}}{\Lambda x^2} + \frac{\psi_{i+1,j} - 2\psi_{i,j} + \psi_{i+1,j}}{\Lambda y^2} = 0 \qquad (2\text{-}11)$$

If grid spacing, $\Lambda x = \Lambda y = h$ then:

$$\nabla^2 \psi_{i,j} = \frac{1}{h^2}\left(\psi_{i+1,j} + \psi_{i-1,j} + \psi_{i,j+1} + \psi_{i,j-1} - 4\psi_{i,j}\right) = 0 \qquad (2\text{-}12)$$

$$\psi_{i,j} = \frac{1}{4}\left(\psi_{i+1,j} + \psi_{i-1,j} + \psi_{i,j+1} + \psi_{i,j-1}\right) \qquad (2\text{-}13)$$

2) Finite element method

Many engineering problems can be described in the form of differential equation. In addition to finite difference method, finite element method is another numerical calculation method used to seek out solutions of differential equations, which is a kind of approximate numerical solution of differential equations.

Parameters estimation algorithm of bubble image segmentation and bubble size probability distribution

In addition to the bubble velocity, bubble size of mineral froth flotation isanother important apparent characteristics of performance indicators reflecting mineral separation. In the lower part of Flotation tank foam layers are most of mall bubbles, where water is much between the water cut, the farther the upper foam layer, the biggergrow bubbles, which is mainly composed of polyhedral big bubbles because the drainage process liquid film between the water cut decreased.

Study of mineral flotation foam image segmentation algorithms

In image analysis and research, some part people interested is referred to as the target or prospects, as opposed to what known as the background. Conventional image segmentation need to pick up the foreground from the background segmentation, and thus for the subsequent measurement and application. Mineral flotation foamobtained in industrial field are of characteristics of whole foreground, no background. We are interested in all of the bubble.The bubble size estimation researchis of great significance to establish operating status and the relationship between bubble shape features. Among methods that use image processing techniques to estimate the bubble size , the method based on image segmentation have been under the spotlight.

Bubble size probability density distribution of parameter estimation algorithms

There are two main types of probability density estimation ideas, namely parameter estimation and the non-parameter estimation. Parameter estimation method usually presupposedata samples follow some distribution, the parameters of the distribution function is estimated by training sample data. Rather than a parameter estimation method, non-parameter estimation is not based on the model, in advance sample data model is unknown, only using the sample data itselffor probability density estimation. For probability density estimation, non-parametric estimation method is suitable for the analysis of unknown continuous process. Therefore, in this paper, non-parametric estimation algorithm is used to get the probability density distribution of bubble size. Different from the traditional description of the normal distribution characteristics like, mean value, variance, etc, bubble size tend not to be a Gaussian while parameter estimation method of distribution model has definite limit, which can't describe the uncertainties inherent to the probability density distribution of bubble size. Typical density distribution curve hascharacteristics of left deviation or right deviation and long tail. To describe bubble size distributionaccurately, the non-parametric estimation operator provides a reasonable solution, which can also reflect the various complex relationships.

Summary

Based on the background of mineral froth flotation production process, this paper studies bubbles apparent feature extraction algorithm that based on computer vision on the light of the complexity of flotation process and opaque, incomprehensibility of flotation foam. It is used to analyzethe the qualitative relationship between apparent characteristics, operating condition parameters. Bubble apparent characteristics, operating conditions, and foam flotation performance index correlation model was set up and applied to the optimization of oxidealuminum flotation index problem.

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