

Numerical simulation of flow field of inflation pressure for large complex sulfide mineral of low-tin flotation machine

Hu Mingzhen^a, Wu Bozeng^b, Chen Jinquan^c, Zeng Jishu^d

CHINA TIN GROUP CO. , LTD. Liuzhou Guangxi China

^ahmz369hn@126.com, ^bwubz@china-tin.com, ^ccjq20088ok@163.com, ^dzengjishu@sohu.com

Keywords: Complex sulfide mineral; Low-tin flotation machine; Inflation pressure; Multiphase flow characteristics; Numerical simulation.

Abstract: For flotation characteristics of complex sulfide mineral of low-tin in Guangxi Dachang mine, fluid dynamics software FLUENT was applied to simulate the turbulence intensity of slurry fluid in flotation machine at different inflation pressures. The effect of flow field characteristics was gotten for flotation machine. Simulation results show that the best inflation pressure was 120000 Pa.

Introduction

Flotation is considered to be the most popular process for mineral separation. Valuable minerals are separated from worthless material. This research was based on the ability of complex sulfide minerals of low-tin flotation machine. Inflation pressure is one of important factors that decide flotation foam enrichment degree in flotation machine. The proper inflation pressure can form relatively stable separation zone and stable foam layer, preventing the pulp level over the flower, reducing the particle shedding [1,3].

There are some characteristics, such as uneven flotation particles, large size range, obvious difference in specific gravity, similar flotation behavior of different minerals, leading to difficulty of separation. There are many shortcomings of popular flotation machine, such as multiple sets of equipment, high energy consumption, management inconvenience. The influence of inflation pressure of flotation machine was studied through the multi phase flow simulation. The fruitful results will contribute a lot to the theoretical basis and technical guidance of development of large complex sulfide minerals of low-tin flotation machine.

Flotation mechanism

Complex sulfide mineral of low-tin flotation machine is mainly composed of impeller, stator, air pipe, tank body, motor device, guiding shell and so on.

Vacuum zone is formed when slurry is mixed by high-speed impeller. At the same time the air is injected through air pipe and then is broken into even small bubbles by high-speed impeller. Valuable minerals in bubbles are floated up under buoyancy.

In the flotation process, the fluid dynamics morphology of slurry in flotation tank is a complicated three-phase mixing system [4]. Slurry was fully suspended under the inflatable pressure, which ensures the full contact and increases the collision probability among the mineral particles and bubbles. However, the inflation pressure should be kept at a reasonable extent. Otherwise it would cause over the flower in plasma surface and worsen the flotation environment. Therefore, the optimization of inflation pressure plays an important role to achieve an excellent flotation effort.

Simulation model

Basic hypothesis

The medium in tank is a mixture made up of water, mineral particles and air [5, 6]. The slurry concentration is 15%. The simulation parameters are supposed as follows: the grain size 74 μm , the

density 3100 kg/m³, and the bubble diameter 1 mm. The assumption is on the basis of material characteristics of Guangxi Dachang.

The basic assumptions are as follows:

- (1) Three-phase pressure is equivalent in the same computing element;
- (2) Bubble and particle are rigid spheres with constant size.

In the numerical simulation, mixture model was used to solve the problem of three-phase flow of flotation machine. The pressure-velocity was interacted by SIMPLEC algorithm. Multiple reference frame method (MRF) and standard κ - ϵ model were adopted to calculate turbulence zone.

Computational zone

The whole fluid region in flotation machine was divided into four regions based on the region differences of three-phase flow. The multiple reference coordinate system (MRF) was adopted to solve no-slip region in which the fluid around impeller rotated with impeller. The air column in pipe was the air zone. The extension of slurry inlet was a separated zone. The rest was the three-phase flow zone which was affected by flow of impeller. Coupled surface was used to connect each computational zone.

Boundary condition

The impeller surface was set as turning border, and the other walls of the tank were supposed to be no-slipping boundary conditions. The parameters adopted in the simulation model were listed as follows:

(1) The pressure boundary was adopted for the boundary of slurry inlet, and the pressure was assumed to be 1 atm. The solid-liquid-gas phase fraction was supposed to be 0.3, 0.7 and 0, respectively.

(2) The pressure boundary was also adopted on gas inlet boundary of the calculation zone, and the pressure was assumed to be 1 atm. The solid-liquid-gas phase fraction was supposed to be 0, 0 and 1.0, respectively.

(3) The pressure boundary condition of outlet was applied on the output boundary of overflow bubbles. The average pressure of outlet was set to be 1 atm on the basis of real production environment.

(4) The pressure boundary condition of outlet was also applied on the slurry output boundary of calculation zone. The pressure was set to be 1.13 atm, which was calculated from the method of large orifice flow.

Import and export condition

The speed of inlet along the slurry pipe was supposed to be uniform in which the flow of slurry was 900m³/h. And the speed of entry was 2.6m/s.

The boundary grid of slurry inlet and the pressure outlet of body were composed of triangle meshes. The boundary grid air inlet was made up of triangle mesh and boundary layer mesh.

Simulation results

Pulp flow under different inflation pressures

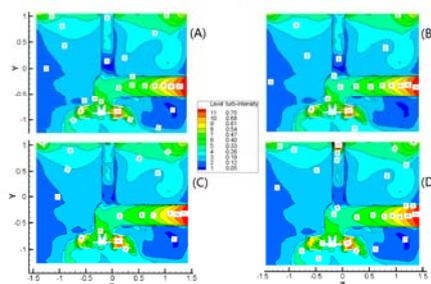


Fig.1 Turbulence intensity distribution in X-Z direction with the inflation pressure (A) 120000 (B) 140000 (C) 160000 (D) 180000Pa

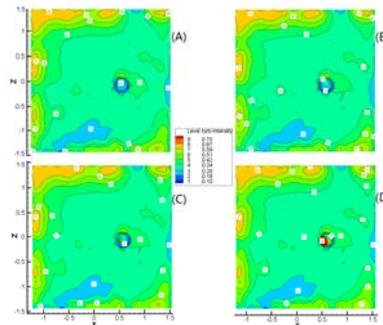


Fig.2 Turbulence intensity distribution in top surface with the inflation pressure (A) 120000 (B) 140000 (C) 160000 (D) 180000Pa

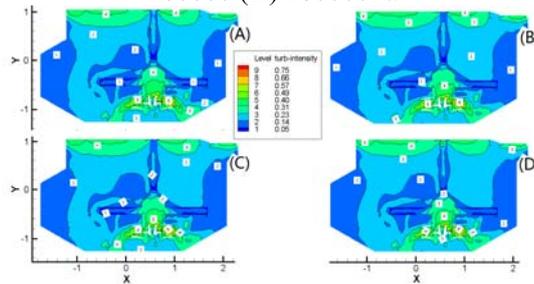


Fig.3 Turbulence intensity distribution in Z=0 direction with the inflation pressure (A) 120000 (B) 140000 (C) 160000 (D) 180000Pa

It can be seen from the figures (Fig.1, Fig.2, Fig.3) that the turbulence intensity of mixing phase in the same position of flotation machine increases from radial to axis, then decreases in 160000 Pa with the increase of inflation pressure. The largest turbulence intensity appeared in the outlet of impeller, which would be good for the crush of big bubble and the mixing of slurry and air.

Gas content of pulp under different inflation pressure

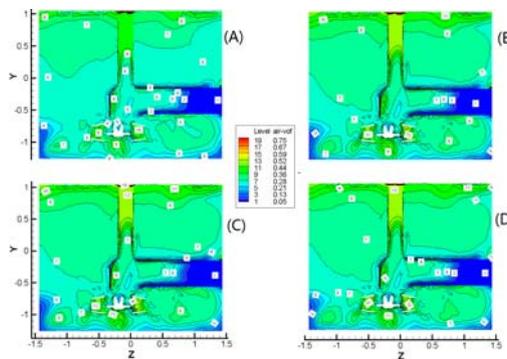


Fig.4 Volume fraction of gas in X=0 direction with the inflation pressure (A) 120000 (B) 140000 (C) 160000 (D) 180000Pa

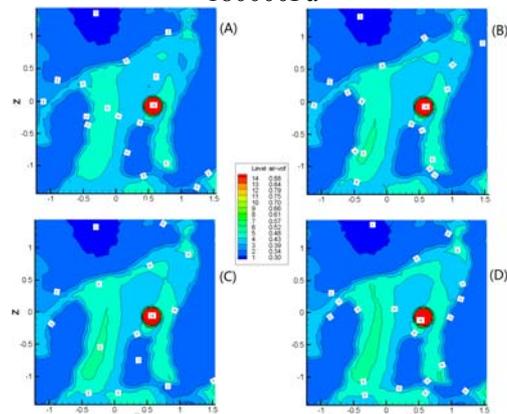


Fig.5 Volume fraction of gas in top surface with the inflation pressure (A) 120000 (B) 140000 (C) 160000 (D) 180000Pa

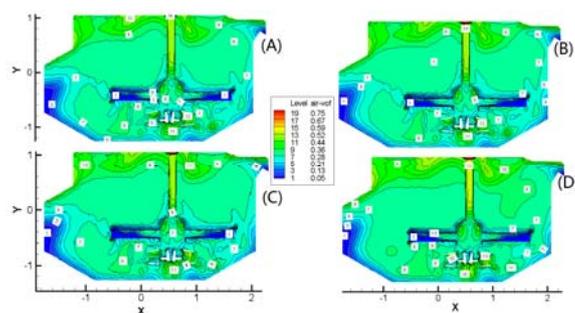


Fig.6 Volume fraction of gas in X-0 direction with the inflation pressure (A) 120000 (B) 140000 (C) 160000 (D) 180000Pa

The foam is gathered rapidly to mineralized foam layer from mixing zone to separating zone. The gas content increases with the addition of inflation pressure. The gas content of slurry would overtake 30% when the inflation pressure is up to 160000 Pa. At this time the slurry would turn flowers out with the increase of inflation pressure.

According to the flotation theory, the best effort of machine appears when the air content is 25% and the pressure is 120000 Pa.

Summary

The fluid dynamics software FLUENT was applied to simulate the multiphase flow characteristics of different inflation pressure in flotation machine. Over high inflation pressure would affect the stability of foam layer. The best inflation pressure is 120000 Pa.

References

- [1] Jameson, G. J. New directions in flotation machine design [J]. *Minerals Eng*, 2010, 23 (11): 835-841.
- [2] Lima, O.A.; Deglon, D.A.; Leal Filho, L.S.. A comparison of the critical impeller speed for solids suspension in a bench-scale and a pilot-scale mechanical flotation cell [J]. *Minerals Engineering*, 2009, 22 (13): 1147-1153.
- [3] Kourunen, Jari¹; Niitti, Timo²; Heikkinen, Lasse M. Application of three-dimensional electrical resistance tomography to characterize gas holdup distribution in laboratory flotation cell [J]. *Minerals Engineering*. 2011, 24 (15): 1677-1686.
- [4] Han, W, Li, R, Yang, R. Redesign of mechanically agitated flotation machine based on interior flow fields simulation [J]. *Minerals Eng*, 2011, 45 (12): 84-88.
- [5] Nasset, Jan E., Hernandez-Aguilar Jose R., Acuna, Claudio. Some gas dispersion characteristics of mechanical flotation machines [J]. *Minerals Eng*, 2006, 19 (6-8): 807-815.
- [6] Chen, W.-Y. Numerical simulation of gas-liquid two-phase jet flow in air-bubble generator [J]. *J. Cent. South Univ. Technol. Eng. Ed.*, 2008, 15(1): 140-144.