Shahrood University of Technology

Journal of Mining and Environment (JME)

Journal homepage: www.jme.shahroodut.ac.ir

Iranian Society of Mining Engineering (IRSME)

On the Importance of Critical Impeller Speed and Complete Gas Dispersion for Enhancing Flotation Kinetics

Hossna Darabi[1], and Faraz Soltani[2*]

1. Department of Mineral Processing, Tarbiat Modares University, Tehran, Iran
2. Department of Mining Engineering, Arak University of Technology, Arak, Iran

Article Info

Received 9 May 2025

Received in Revised form 6 June 2025

Accepted 30 June 2025

Published online 30 June 2025

DOI: 10.22044/jme.2025.16200.3130

Keywords

Mechanical flotation cell

Critical impeller speed

Flotation kinetics

Complete gas dispersion

Abstract

The main characteristic of mechanical flotation cells is to have an impeller, which is responsible for creating particle suspension, gas dispersion, and producing turbulence necessary to create effective bubble-particle interactions. For this purpose, in this paper, the conditions for complete gas dispersion in a Denver laboratory flotation cell have been investigated. Then, the critical impeller speed has been investigated for quartz particles with different size fractions. The effect of complete dispersion of introduced gas and critical impeller speed on the flotation rate constant (k) of particles was investigated. The results showed that k was the minimum value at an impeller speed of 700 rpm in the superficial gas velocity of 0.041- 0.125 cm/s for all size fractions. The impeller speed of 700 rpm was sufficient to keep -106µm quartz particles suspended, but at all superficial gas velocities, the minimum impeller speed required for complete gas dispersion was 850 rpm. Therefore, it can be stated that the reason for the low k value at a stirring speed of 700 rpm is the incomplete distribution of bubbles and particles (+106µm), resulting in a reduced probability of air bubbles colliding with solid particles. By increasing the impeller speed to values greater than 700 rpm, the k value increased, which is due to the complete distribution of particles and air bubbles in the flotation cell (increased probability of bubble-particle collision). Therefore, it is necessary to provide suitable operating conditions for the complete dispersion of air bubbles and also to keep solid particles suspended.

1. Introduction

Mechanical flotation cells are one of the most common flotation cells in mineral processing. For this reason, any inefficiency in the flotation process leads to significant financial losses in mineral processing plants. Therefore, many researchers are seeking to increase their knowledge and understanding of the flotation process. Since the flotation process occurs in an aqueous environment, the interaction between particles and bubbles is strongly influenced by the hydrodynamic forces generated by the surrounding liquid and the relative motion between bubbles and particles. Although advances in the understanding of flotation chemistry have improved the flotation process, especially the flotation of fine particles, optimizing the flotation hydrodynamic environment can also significantly improve the flotation process. The flow regime in mechanical flotation cells is turbulent. Turbulence generated by the impeller affects the flotation process in the mechanical cell by affecting macroprocesses (particle suspension and gas dispersion) and microprocesses (bubble-particle collision, attachment, and stability) [1-3]. As a result, optimizing flotation performance requires a detailed understanding of the effect of turbulence on hydrodynamics, particle suspension, gas dispersion, and bubble-particle interactions [4-7]. Therefore, the first step in properly conducting a flotation experiment is to create suitable agitation conditions for the complete dispersion of air bubbles and complete suspension of mineral particles in the flotation cell so that the necessary conditions for bubble-particle interactions (bubble-

Corresponding author: faraz.soltani@arakut.ac.ir (F. Soltani)

particle collision, bubble-particle attachment, and stability) and, consequently, the flotation process are provided. If the bubbles and particles are not completely distributed in the flotation cell, the probability of particle collection is reduced. The literature review indicates a gap in previous studies, as they have not investigated the simultaneous study of complete gas dispersion and complete particle suspension and their effects on the flotation rate constant. Therefore, in this paper, the conditions for complete gas dispersion in a Denver laboratory flotation cell were investigated. The critical impeller speed (the lowest impeller speed required to keep all solid particles suspended at the bottom of the cell) was investigated to ensure proper agitator conditions for particle suspension. Then, the effect of complete gas dispersion conditions and critical impeller speed on the flotation rate constant using pure quartz particles at different size fractions was investigated.

1.1. Complete gas dispersion condition

In a mechanical flotation cell, air is collected in low-pressure cavities behind the agitator blades after being delivered via the rotor-stator in either an external or self-aerating system. As the agitator rotates and shears these air cavities, small and large bubbles are produced. High turbulence in the impeller zone causes the large bubbles to break into small bubbles. The bubbles are then dispersed throughout the cell by the impeller pumping action and fluid circulation. The upward movement of the air bubbles causes the turbulence in the cell to change. Energy is introduced into the flotation cell in the form of kinetic energy through the impeller. Initially, energy is transferred through the primary eddies in the system. The number of eddies increases as their size decreases, but their overall energy drops. Large-scale eddies are known as macroturbulence. The energy of these eddies is used to suspend and transport particles and bubbles. Smaller eddies, i.e., eddies in the inertial subrange and dissipation subrange, are known as micro turbulence. The energy of these eddies is used to disperse the air into small bubbles and to cause bubble-particle collisions, attachment, and detachment [1]. The bubbles formed in the area near the impeller are carried along with the radial flow generated by the impeller and are dispersed throughout the pulp in the flotation cell. The bubbles then rise in the cell due to buoyancy force but are randomly dragged around by the turbulence in the cell. In flotation cells, the aeration number and the ratio of power consumption under non-aerated to aerated conditions can be used to describe gas dispersion and mixing efficiency [8, 9].

As air bubbles enter the cell with a radial flow impeller, three types of flow patterns are created due to the way the bubbles disperse, depending on the impeller speed and the superficial gas velocity. The impeller is considered flooded when there is an axial flow of gas through the impeller plane that reaches the surface of the free liquid (as shown in Figure 1A). By increasing the impeller speed beyond the critical threshold Nf, the impeller is loaded (refer to Figure 1B), with gas moving across the entire area above the impeller. If the impeller speed is further raised above the critical level N_{CD}, a greater dispersion of gas and liquid occurs both above and below the impeller plane (illustrated in Figure 1C) [10, 11]. Determining the minimum impeller speed necessary for complete gas dispersion (N_{CD}) is crucial for gaining insights into the flow pattern in a flotation cell [12]. The ratio of power input under aerated conditions (P_g) to un-aerated (P_u) conditions typically falls within the range of 30% to 100%, depending on the impeller type and the superficial gas velocities applied. This ratio provides insight into the properties of gas dispersion in addition to showing the actual power input [6]. Analyzing the ratio of unaerated to aerated power input (P_g/P_u) in relation to the aeration number (N_Q) is vital for identifying the minimum impeller speed needed for complete gas dispersion in the cell. Specifically, at a certain superficial gas velocity, the impeller speed that minimizes this ratio is referred to as the N_{CD}. These conditions of complete gas dispersion are marked by a bubbly fluid flow pattern, ensuring that there is no flooding around the impeller [13].

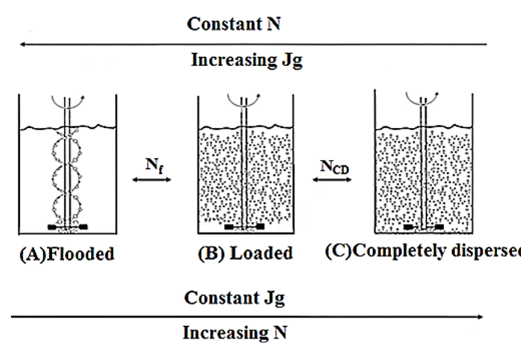

Figure 1. Schematic picture of the bulk flow patterns.

Aeration number (N_Q) can be calculated using the following equation: $N_Q = Q_g/ND^3$, where Q_g denotes the total volumetric gas flow rate, N represents the impeller speed, and D is the impeller diameter [9].

1.2. Critical impeller speed (N_{js})

Achieving effective solids suspension is crucial for particle collection and depends greatly on the hydrodynamic conditions within the cell [14]. The first step of this process is to lift the solids off the bottom, and the second is to spread and distribute them evenly throughout the cell [9, 15]. Consequently, methods for evaluating solids suspension typically focus on either the conditions for off-bottom suspension (e.g., the critical impeller speed) or the conditions for solids distribution (e.g., the suspension height). In the literature, the critical impeller speed, denoted as N_{js}, is frequently referenced as the primary criterion for assessing the effectiveness of solids suspension. This speed is defined as the minimum impeller speed required to lift all solids fully off the bottom of the cell [16-18].

2. Materials and Methods

The tests were conducted using a Denver flotation cell with a capacity of 10.5 L. The cell bottom's square shape was created by its 20 cm by 20 cm dimensions. The stator consisted of 12 blades with a diameter of 12 cm, while the impeller was composed of 8 blades with a diameter of 9 cm. Additionally, the impeller and cell bottom were separated by 2 cm (off-bottom clearance). The impeller's rotational speed, N, was fixed at 700, 850, and 1000 revolutions per minute. The superficial gas velocity was 0.041, 0.083, and 0.125 cm/s.

It is widely recognized that the flotation rate constant is affected by mineral liberation, differences in mineral texture, and variations in gangue type. Additionally, the viscosity of the pulp is affected by the composition of the gangue, especially when clay minerals are included in the flotation feed. This research aims to investigate the effect of complete gas dispersion and critical impeller speed on the flotation rate constant. Consequently, pure quartz particles (particle density 2.65 g/cm^3) were employed to remove the possible influence of mineral liberation and variations in gangue type on flotation kinetics. The pure quartz sample was prepared by Technosilis Corporation (Tehran, Iran). After screening, the sample was divided into seven size classes: coarse particles (-300+212 and -212+150 µm), medium particles (-106+75 and -150+106 µm), and fine particles (-75+53, -53+38, and -38 µm). All samples were rinsed with distilled water to prevent any coated fine quartz particles. The pulp density was considered 5%. Under a pH of 9, pure quartz exhibits a robust negative charge and achieves complete dispersion. Consequently, quartz suspensions exhibit no yield stresses at low solid concentrations (< 10% solids by volume) [19, 20]. In flotation cells, conditions resembling an ideal suspension may be approximately met only when volume fractions of solids are below 0.05 to 0.1. Under these circumstances, the impact of particles on turbulence can be disregarded [1]. The frother concentration of 22.4 ppm (C/CCC = 2) methyl isobutyl carbinol (MIBC) was employed. Additionally, dodecyl amine was utilized as the collector at a concentration of 2.837×10^{-5} mol/L at pH = 9. Concentrates were collected at consistent intervals of 30, 60, 120, 180, 240, 360, and 480 seconds, each collected into separate containers. Throughout the process, water was added to sustain the pulp level within the flotation cell. The concentrates and tailings were subjected to drying and subsequent weighing. Following this, the recovery (R_i) was calculated as a function of time. It has been established that the lab-scale flotation process operates as a first-order rate process [21, 22]. Hence, the flotation rate constant was determined by the following equation:

$$R_i = R_{max}\left(1 - e^{-kt}\right) \quad (1)$$

where k is the flotation rate constant (1/min), t is time (min), and R_{max} is a recovery (%) at time infinity (ultimate recovery). The non-linear least squares regression method was used to calculate k and R_{max} for each particle size range using Eq. (1).

2.1. Power input

In order to find the ratio of unaerated to aerated power input (P_g/P_u), the torque was measured under both unaerated and aerated conditions. Each measurement was repeated three times, and the average power consumption and standard deviation were determined for each set of test conditions. The power input (P) by the impeller at both conditions was calculated as follows [23]:

$$P = \frac{2\pi TN}{60} \quad (2)$$

where T is the stirring shaft torque.

2.2. Critical impeller speed (N_{js})

By gradually increasing the impeller speed from 300 rpm while looking at the flotation cell's bottom through an inclined mirror that was lit by a light source, the critical impeller speed required for total suspension, or N_{js}, was determined (Figure 2). The 1s-criterion, introduced by Zwietering in 1958 [18] and widely adopted by other researchers [16, 17, 24], was utilized to visually assess the just-suspended state.

3. Results and Discussion

3.1. Critical impeller speed (N_{js})

Table 1 presents the findings of the critical impeller speed measurements. The minimum required impeller speed for particles of -106+74 µm at an aeration rate of 0.041 cm/s is 705 rpm, and the maximum required impeller speed for particles of -300+212 µm at the superficial gas velocity of 0.125 cm/s is 1010 rpm. Therefore, the impeller speed range between 700 and 1000 rpm was selected for the experiments. Since the other size classes selected for the flotation experiments are smaller than the -106+74 µm particles, it can be stated that this impeller speed range is suitable for all selected size classes.

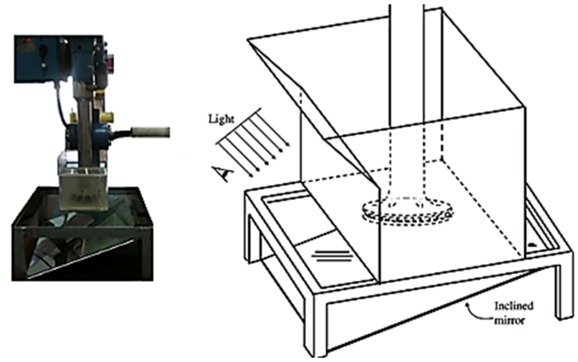

Figure 2. Experimental scheme used to measure the critical impeller speed.

Table 1. Critical impeller speed (N_{js}) for particles with different size classes at different superficial gas velocities.

Superficial gas velocity (cm/s)	Particle size (µm)	N_{js} (rpm)
0	-106+74	660
0.041	-106+74	705
0.083	-106+74	765
0.125	-106+74	880
0	-150+106	740
0.041	-150+106	805
0.083	-150+106	825
0.125	-150+106	920
0	-212+150	775
0.041	-212+150	855
0.083	-212+150	915
0.125	-212+150	985
0	-300+212	935
0.041	-300+212	970
0.083	-300+212	985
0.125	-300+212	1010

3.2. Critical impeller speed (N_{js})

In Figure 3, the ratio of power consumption under aerated conditions to power consumption under non-aerated conditions (P_g/Pu) is plotted as a function of the aeration number (N_Q) at different impeller speeds. The P_g/P_u ratio was 0.82 to 1. In this figure, the minimum speed required for complete dispersion of introduced gas (N_{CD}) is presented as the impeller speed at which the P_g/P_u ratio is minimum at a given superficial gas velocity. At all superficial gas velocities, the N_{CD} was equal to 850 rpm. It can be stated that in the superficial gas velocity range of 0.125-0.041 cm/s, an impeller speed of 700 rpm is not sufficient for complete gas dispersion in the cell. Consequently, impeller speeds greater than 850 rpm must be used for flotation experiments.

3.3. Influence of complete dispersion of introduced gas and critical impeller speed on the flotation kinetics

In order to investigate the relationship between flotation rate constant (k), N_{js} and N_{CD}, for each of the size classes of quartz particles studied in this paper, the flotation rate constant for impeller speeds of 700, 850, and 1000 rpm at the superficial gas velocities of 0.125-0.041 cm/s is investigated in Figure 4.

The results show that k has the minimum value at the impeller speed of 700 rpm and the superficial gas velocities of 0.125-0.041 cm/s for all size classes. According to the results, the impeller speed of 700 rpm is sufficient to keep quartz particles smaller than 106 µm in suspension, but at all superficial gas velocities, the N_{CD} obtained is equal to 850 rpm. Therefore, it can be stated that the reason for the low k value at the impeller speed of 700 rpm is the lack of complete distribution of air and particles (larger than 106 µm) in the flotation cell, resulting in a decrease in the bubble-particle collision probability. The flotation rate kinetics of particles smaller than 106 µm increased at impeller speeds of 850 rpm (equivalent to N_{CD} 1.2 N_{js}) to 1000 rpm (equivalent to 1.5 N_{js}), as shown in Figure 4, because particles have a more uniform spatial distribution in the flotation cell at these impeller speeds [4]. On the other hand, the N_{CD} was obtained to be equal to 850 rpm. Therefore, when the impeller speed is between 850 and 1000 rpm, we can say that k values increase because bubbles and particles are evenly distributed throughout the flotation cell, increasing the likelihood of collisions between the two [2]. However, k for particles larger than 106µm decreases as the impeller speed increases above 850 rpm because particles and air bubbles are more likely to separate from one another, even though the particles and bubbles are still evenly distributed [3]. Therefore, it is necessary to provide suitable operating conditions for the complete dispersion of air bubbles and also to keep solid particles suspended to provide optimal flotation conditions.

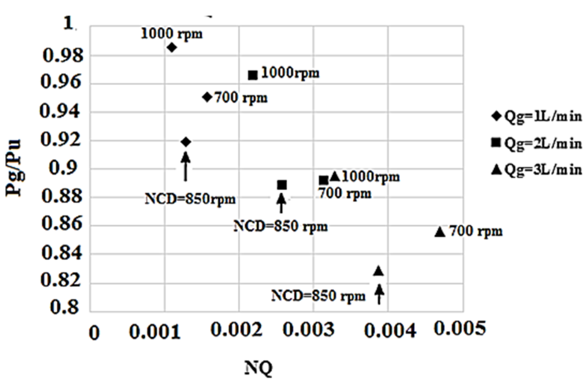

Figure 3. The relationship between N_Q and P_g/P_u

5. Conclusions

This paper investigated the conditions for complete gas dispersion in a Denver laboratory flotation cell. The critical impeller speed was investigated to ensure the creation of suitable agitation conditions for particle suspension. Then, the effect of complete gas dispersion conditions and critical impeller speed on the flotation rate constant using pure quartz particles was investigated. The results of the investigation of the conditions for complete gas dispersion showed that in the range of the superficial gas velocities of 0.125-0.041 cm/s, the impeller speed of 700 rpm was not sufficient for complete gas dispersion in the cell. Therefore, it is necessary to conduct flotation experiments at impeller speeds higher than 850 rpm. The minimum critical impeller speed for particles of -106+74 µm at the superficial gas velocity of 0.041 cm/s was 705 rpm, and the maximum required impeller speed for particles of -300+212 µm at the superficial gas velocity of 0.125 cm/s was 1010 rpm. Since the other size classes selected for flotation experiments are smaller than the -106+74 µm particles, it can be stated with certainty that this impeller speed range of 700-1000 rpm is suitable for all selected size classes. For an impeller speed of 700 rpm in the range of the superficial gas velocity of 0.125-0.041 cm/s for all size classes, k has the minimum value. According to the results of the critical impeller speed determination experiments, the impeller speed of 700 rpm was sufficient to keep quartz particles smaller than 106 µm in suspension, but at all the superficial gas velocities, N_{CD} (the minimum impeller speed required for complete gas dispersion) was obtained at 850 rpm. Therefore, it can be stated that the reason for the low k value at the impeller speed of 700 rpm is the lack of complete distribution of bubbles and particles (larger than 106 µm) in the flotation cell, and as a result, the probability of bubble-particle collision is reduced. Because of the full distribution of air and the more even spatial distribution of particles in the flotation cell, the flotation rate kinetics of particles smaller than 106 µm increased at impeller speeds of 850 to 1000 rpm. The likelihood of a bubble-particle collision then increased. Despite the overall particle and bubble distribution, k for particles larger than 106µm was decreased by increasing the impeller speed to values greater than 850 rpm. The higher detachment efficiency of particles and air bubbles may be the cause of this. Therefore, it is essential to provide suitable operating conditions for the complete dispersion of air bubbles and also to keep solid particles suspended to provide optimal flotation conditions.

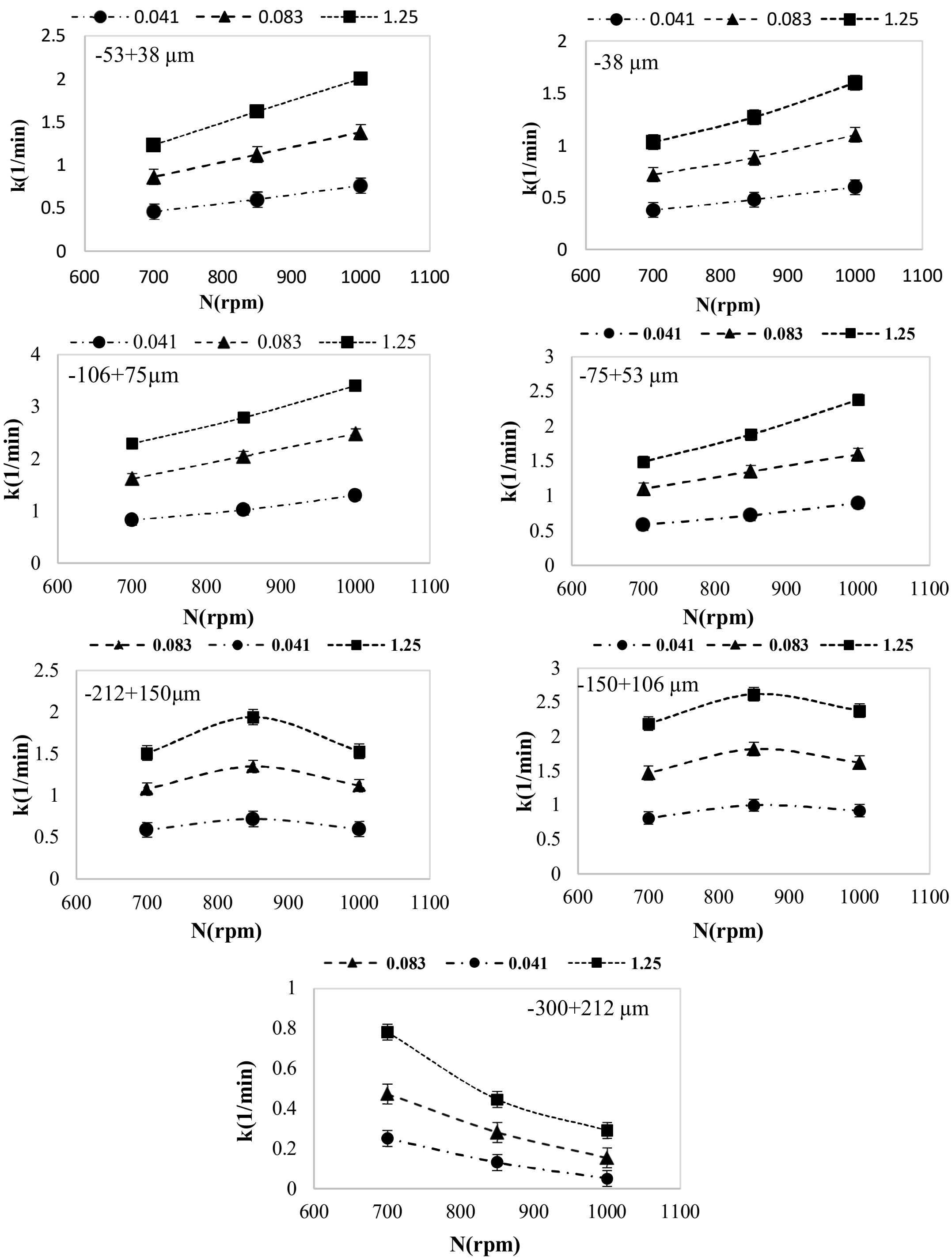

Figure 4. The relationship between impeller speed and flotation rate constant at different particle sizes and superficial gas velocities.

6. References

[1]. Schubert, H. (1999). On the turbulence-controlled microprocesses in flotation machines. *International journal of mineral processing, 56*(1-4), 257-276.

[2]. Darabi, H., S.J. Koleini, D. Deglon, B. Rezai, and M. Abdollahy. (2019). Investigation of bubble-particle interactions in a mechanical flotation cell, part 1: Collision frequencies and efficiencies. *Minerals Engineering, 134*, 54-64.

[3]. Darabi, H., S.J. Koleini, D. Deglon, B. Rezai, and M. Abdollahy. (2020). Investigation of bubble-particle attachment, detachment and collection efficiencies in a mechanical flotation cell. *Powder Technology, 375*, 109-123.

[4]. Darabi, H., S.M.J. Koleini, B. Rezai, and M. Abdollahy. (2017). The Investigation of Critical Impeller Speed in a Laboratory Mechanical Flotation Cell. *Nashrieh Shimi va Mohandesi Shimi Iran, 36*(3), 211-223.

[5]. Darabi, H., S.M.J. Koleini, F. Soltani, M. Abdollahy, and M. Ghadiri. (2020). Investigation of cell geometry effect on the turbulence characteristics and flotation performance using particle image velocimetry technique. *Powder Technology, 376*, 458-467.

[6]. Shen, Z. and Z. Shen. (2021). Dynamic Characteristics and Evaluation of Flotation Machines. *Principles and Technologies of Flotation Machines*, 59-83.

[7]. Darabi, H., F. Soltani, and D. Deglon. (2024). Enhancing flotation kinetics: Investigating hydrodynamic impact for improved predictive modeling. *Minerals Engineering, 215*, 108832.

[8]. Harris, C. (1974). Impeller speed, air, and power requirements in flotation machine scale-up. *International Journal of Mineral Processing, 1*(1), 51-64.

[9]. Harris, C. and R. Mensah-Biney. (1977). Aeration characteristics of laboratory flotation machine impellers. *International Journal of Mineral Processing, 4*(1), 51-67.

[10]. Paglianti, A. (2002). Simple model to evaluate loading/flooding transition in aerated vessels stirred by Rushton disc turbines. *The Canadian Journal of Chemical Engineering, 80*(4), 1-5.

[11]. Lins Barros, P., F. Ein-Mozaffari, and A. Lohi. (2022). Gas dispersion in non-Newtonian fluids with mechanically agitated systems: A review. *Processes, 10*(2), 275.

[12]. Nienow, A. Effect of scale and geometry on flooding, recirculation and power in gassed stirred vessels. *in 2nd Euro, Conf. Mixing, Cambridge, England*. 1977.

[13]. Yawalkar, A.A., A.B. Heesink, G.F. Versteeg, and V.G. Pangarkar. (2002). Gas—liquid mass transfer coefficient in stirred tank reactors. *The Canadian Journal of Chemical Engineering, 80*(5), 840-848.

[14]. Schubert, H. and C. Bischofberger. (1998). On the microprocesses air dispersion and particle-bubble attachment in flotation machines as well as consequences for the scale-up of macroprocesses. *International journal of mineral processing, 52*(4), 245-259.

[15]. Arbiter, N., C. Harris, and R. Yap. (1969). Hydrodynamics of flotation cells. *SME Transactions, 244*, 134-148.

[16]. Van der Westhuizen, A. and D. Deglon. (2007). Evaluation of solids suspension in a pilot-scale mechanical flotation cell: The critical impeller speed. *Minerals Engineering, 20*(3), 233-240.

[17]. Van der Westhuizen, A. and D. Deglon. (2008). Solids suspension in a pilot-scale mechanical flotation cell: A critical impeller speed correlation. *Minerals Engineering, 21*(8), 621-629.

[18]. Zwietering, T.N. (1958). Suspending of solid particles in liquid by agitators. *Chemical engineering science, 8*(3-4), 244-253.

[19]. Ndlovu, B., M. Becker, E. Forbes, D. Deglon, and J.-P. Franzidis. (2011). The influence of phyllosilicate mineralogy on the rheology of mineral slurries. *Minerals engineering, 24*(12), 1314-1322.

[20]. Ndlovu, B., E. Forbes, M. Becker, D. Deglon, J. Franzidis, and J. Laskowski. (2011). The effects of chrysotile mineralogical properties on the rheology of chrysotile suspensions. *Minerals Engineering, 24*(9), 1004-1009.

[21]. Ralston, J., The influence of particle size and contact angle in flotation, *in Developments in mineral processing. 1992, Elsevier*. p. 203-224.

[22]. Jameson, G., S. Nam, and M.M. Young. (1977). Physical factors affecting recovery rates in flotation. *Miner. Sci. Eng.;(South Africa), 9*(3).

[23]. Gui, X., G. Cheng, J. Liu, Y. Cao, S. Li, and Q. He. (2013). Effects of energy consumption on the separation performance of fine coal flotation. *Fuel Processing Technology, 115*, 192-200.

[24]. Lima, O.A.d., D.A. Deglon, and L.d.S. Leal Filho. (2009). A comparison of the critical impeller speed for solids suspension in a bench-scale and a pilot-scale mechanical flotation cell. *Minerals Engineering, 22*(13), 1147-1153.

انجمن مهندسی معدن ایران
نشریه مهندسی معدن و محیط زیست
نشانی نشریه: www.jme.shahroodut.ac.ir
دانشگاه صنعتی شاهرود

اهمیت سرعت بحرانی همزن و پراکندگی کامل گاز در افزایش سینتیک فلوتاسیون

حسنا دارابی[1] و فراز سلطانی[2*]

۱. دکتری فرآوری مواد معدنی، گروه فرآوری مواد معدنی، دانشگاه تربیت مدرس، تهران، ایران
۲. گروه مهندسی معدن، دانشکده مهندسی علوم زمین، دانشگاه صنعتی اراک، مرکزی، ایران

اطلاعات مقاله

تاریخ ارسال: ۲۰۲۵/۰۵/۰۹
تاریخ داوری: ۲۰۲۵/۰۶/۰۶
تاریخ پذیرش: ۲۰۲۵/۰۶/۳۰

DOI: 10.22044/jme.2025.16200.3130

کلمات کلیدی

سلول فلوتاسیون مکانیکی
سرعت بحرانی همزن
سینتیک فلوتاسیون
پراکندگی کامل گاز

چکیده

مشخصه اصلی سلول‌های فلوتاسیون مکانیکی داشتن همزن است که وظیفه ایجاد سوسپانسیون ذرات جامد، پراکندگی گاز و تولید تلاطم لازم برای ایجاد اندرکنش‌های مؤثر حباب- ذره را بر عهده دارد. به همین دلیل در این مقاله، شرایط پراکندگی کامل گاز در یک سلول فلوتاسیون آزمایشگاهی مدل دنور بررسی شده است. سپس سرعت بحرانی همزن برای ذرات کوارتز خالص با محدوده های ابعادی مختلف بررسی شد. تأثیر پراکندگی کامل گاز و سرعت بحرانی همزن بر ثابت سینتیک فلوتاسیون (k) بررسی شد. نتایج نشان داد که k برای تمام ذرات در سرعت همزن ۷۰۰ rpm و سرعت ظاهری هوا ۰/۰۴۱- ۰/۱۲۵ cm/s حداقل مقدار بود. سرعت همزن ۷۰۰ rpm برای پراکندگی ذرات ۱۰۶- میکرون کافی بود اما در تمام سرعت های ظاهری هوا، حداقل سرعت همزن لازم برای پراکندگی کامل گاز برابر با ۸۵۰ rpm بود. بنابراین می توان بیان کرد که دلیل کم بودن مقدار k در سرعت همزن ۷۰۰ rpm توزیع ناکافی حباب ها و ذرات (۱۰۶+ میکرون) و در نتیجه کاهش احتمال برخورد حباب های هوا با ذرات جامد است. با افزایش سرعت همزن به مقادیر بیشتر از ۷۰۰ rpm، به دلیل توزیع کامل ذرات و حباب های هوا در سلول فلوتاسیون (افزایش احتمال برخورد حباب- ذره)، k افزایش می یابد. بنابراین ایجاد شرایط مناسب عملیاتی برای توزیع کامل حباب های های هوا و سوسپانسیون ذرات ضروری است.

نویسنده مسئول مکاتبات: faraz.soltani@arakut.ac.ir (ف. سلطانی)