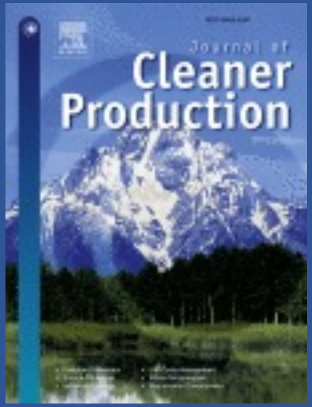
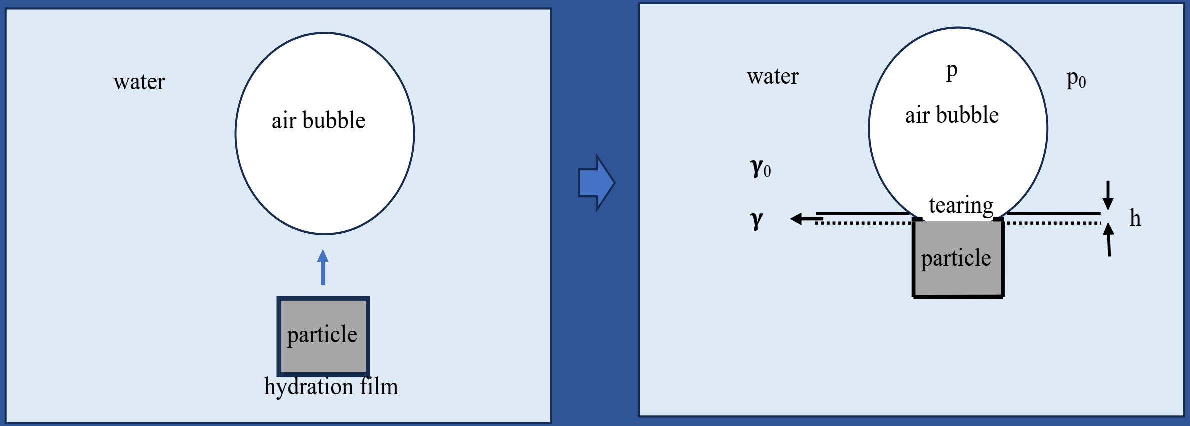
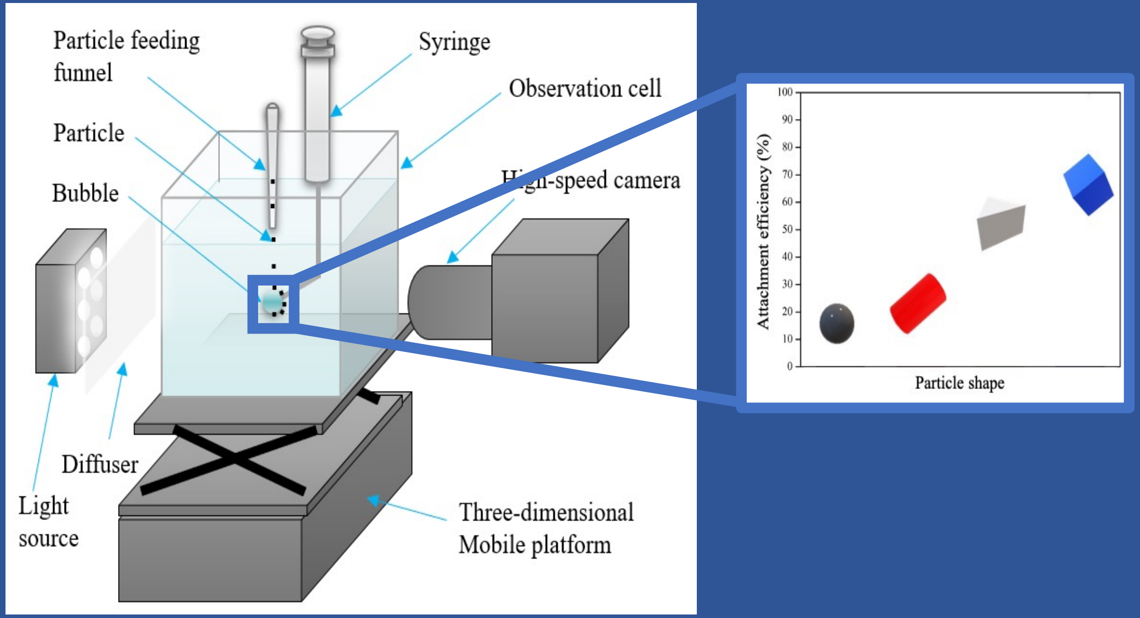
New Research has identified cubic particles are the most favored shape in flotation by attachment tests





Improving the flotation efficiency of fine particles has become a focal point of research among scholars and the industrial community



In a paper published in the Journal of Cleaner Production, the scientists behind the study explain that the edge facilitates the drainage, thinning, and rupture of the water film between the bubble and the particle, thereby increasing attachment efficiency.

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Effect of particle shape on bubble-particle attachment behavior: Roles of surfaces, edges, and vertexes

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ABSTRACT

It has been understood through many studies that particle shape is important in terms of particle adhesion to air bubbles in flotation. However, there are many questions yet to be answered. Whether the surface of the particle or its sharp corners is effective is only one of the issues that need to be better understood. Therefore, this study aims to delve deeper into the fundamental studies on the role of particle's geometry (surface, edges, and vertex) in their flotation behavior by investigating the attachment of spherical, cylindrical, triangular prismatic, and cubic particles to air bubbles based on their attachment efficiency, settling velocity, collision efficiency, and induction time. Bubble-particle attachment test results inferred that the attachment efficiency was in the order of cubic > triangular > cylindrical > spherical. In addition, it was found that the induction time of the spherical surface decreased from 37 ms to 15 ms with increasing collector concentration, while the induction time of the edged cubic particle decreased from 8 ms to 2 ms. This was attributed to the fact that the edge facilitates the drainage, thinning, and rupture of the water film between the bubble and the particle, thereby increasing the attachment efficiency. Finally, it has also been observed that the three-phase contact line of the cube particle is larger than that of the spherical particle, which improves the attachment stability and reduces detachment efficiency. The results obtained in this study shed light on the fact that the shape of the particles fed to flotation can be produced by using a suitable mill and thus higher flotation efficiency can be achieved with lower collector concentration.

1. Introduction

Since the transition to clean energy and emerging technologies currently is only possible with the use of raw materials such as minerals and metals, it is a prerequisite for these metals and minerals to be crushed and ground before their ores, reduced to fine sizes and separated from their gangue by froth flotation after sufficient liberation has been achieved. In other words, the maximum recovery of metals from ore at fine sizes via flotation is the first step toward sustainable exploitation of these essential raw materials (Park and Silwamba, 2023). Therefore, every single process step in the metallurgical industry is currently being reviewed for greater efficiency in the world (Raabe, 2023). Thus, the process efficiency in the flotation, which treats roughly two billion tons of mineral materials annually, around the world becomes important for reducing carbon dioxide (CO_2) emissions as envisaged in the sustainable development goal (SDG) number 13 (Hák et al., 2016).

The particles to be floated must be hydrophobic in order to selectively connect to air bubbles. The formation of a mineral-air interface and the destruction of an equivalent area of mineral-water and air-water interfaces cause a change in free energy during particle-bubble contact (Fuerstenau and Somasundaran, 2003). In this context, it is also known that the fundamental steps in the mineral flotation process (Fig. 1) are the adhesion and stability of the bubble-particle aggregate (Nguyen and Schulze, 2004; Huang et al., 2011; Yoon, 2000; Xing et al., 2017, 2018; Rong et al., 2019; Han et al., 2023).

Although the effective attachment of the mineral particle to the bubble surface is crucial to the flotation process, the process is very challenging to simulate because of the complicated nature of the bubble-

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Highlights

- investigation of the role of particle geometry on bubble-particle attachment.
- surfaces, edges, and vertices of particles with various regular shapes were tested.
- the attachment efficiency order: cubic>triangular>cylindrical>spherical.
- settling velocity order: spherical> cubic>triangular>cylindrical
- the cube had the best attachment efficiencies of all the particles.
- the particle edge favored bubble-particle adhesion.

Scope & Motivation

Since the transition to clean energy and emerging technologies currently is only possible with the use of raw materials such as minerals and metals, it is a prerequisite for these metals and minerals to be crushed and ground before their ores, reduced to fine sizes and separated from their gangue by froth flotation after sufficient liberation has been achieved. In other words, the maximum recovery of metals from ore at fine sizes via flotation is the first step toward sustainable exploitation of these essential raw materials. Therefore, every single process step in the metallurgical industry is currently being reviewed for greater efficiency in the world. Thus, the process efficiency in the flotation, which treats roughly two billion tons of mineral materials annually, around the world becomes important for reducing carbon dioxide (CO_2) emissions as envisaged in the sustainable development goal (SDG) number 13. Since particle geometry such as size and shape are among the most important variables in flotation from the point of view of advanced flotation control and optimizing flotation control, increasing efficiencies in flotation by controlling particle shape by choosing a proper grinding system is related to the theme of "clean production and technical processes".

In the world of flotation processes, the concept of attachment of mineral particles to air bubbles plays a crucial role in determining the efficiency and effectiveness of the process. Since particles fed to flotation are usually ground from a mill, they usually have non-spherical, angular, or sharp-edged surfaces. Thus, the presence of high-density edges and corners of the ground particles for the formation of three-phase contact in flotation plays an important role in the adhesion efficiency of particles to the air bubble. Thus, understanding the attachment of particle surfaces, corners, and vertexes is essential for optimizing these processes and achieving desired separation outcomes. Therefore, this study aims to delve deeper into the fundamental studies on the role of particle shape in their flotation behavior by investigating the attachment of spherical, cylindrical, triangular prismatic, and cubic particles to air bubbles.

Abstract:

It has been understood through many studies that particle shape is important in terms of particle adhesion to air bubbles in flotation. However, there are many questions yet to be answered. Whether the surface of the particle or its sharp corners is effective is only one of the issues that need to be better understood. Therefore, this study aims to delve deeper into the fundamental studies on the role of particle’s geometry (surface, edges, and vertex) in their flotation behavior by investigating the attachment of spherical, cylindrical, triangular prismatic, and cubic particles to air bubbles based on their attachment efficiency, settling velocity, collision efficiency, and induction time. Bubble-particle attachment test results inferred that the attachment efficiency was in the order of cubic>triangular>cylindrical>spherical. In addition, it was found that the induction time of the spherical surface decreased from 37 ms to 15 ms with increasing collector concentration, while the induction time of the edged cubic particle decreased from 8 ms to 2 ms. This was attributed to the fact that the edge facilitates the drainage, thinning, and rupture of the water film between the bubble and the particle, thereby increasing the attachment efficiency.

Finally, it has also been observed that the three-phase contact line of the cube particle is larger than that of the spherical particle, which improves the attachment stability and reduces detachment efficiency. The results obtained in this study shed light on the fact that the shape of the particles fed to flotation can be produced by using a suitable mill and thus higher flotation efficiency can be achieved with lower collector concentration.