学 位 論 文 内 容 の 要 旨

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学 位 論 文 題 名

Development of Carrier-Flotation Technique for Finely Ground Copper Sulfides
(微粒硫化銅鉱のキャリア浮選法の開発)

Copper (Cu) is one of the most important metals required to meet the world′s growing energy production, storage, and transportation needs. Porphyry copper deposits (PCDs) make up a large portion of the world′s economic copper resources. Porphyry copper deposits contain hundreds of millions of tons of ore averaging only a fraction of 0.44% copper. Although PCDs are low-grade, they are important because they can be mined at a low cost on a large scale.
Flotation is a common mineral processing method used to produce copper concentrates from copper sulfide ores. In this method, copper sulfide minerals are concentrated in the froth while associated gangue minerals are separated as tailings. However, some amount of copper is lost to tailings during the processing; therefore, tailings can be considered secondary resources or future deposits of copper. The particle sizes of copper sulfide minerals present in tailings are typically very fine because of the adoption of the regrinding process before cleaner flotation for improving the degree of liberation. Ultrafine particles are least likely to collide with air bubbles in the flotation cell, resulting in the lowering of their recovery by conventional flotation techniques. Therefore, the development of flotation methods able to recover fine particles effectively is necessary for processing tailings. For this, this study investigated an innovative method called carrier flotation using coarse chalcopyrite and pyrite as carriers for improving the recovery of finely ground chalcopyrite particles.
Chapter 1 describes the statement of the problem and the objectives of this study.
Chapter 2 reviews the comparison of different techniques to recover copper sulfides from flotation tailings, including column flotation, microbubble flotation, nanobubble flotation, polymer flocculation, shear flocculation, oil agglomeration, and carrier flotation.
In Chapter 3, the effects of coarse chalcopyrite particles as a carrier on flotation behavior of fine chalcopyrite were investigated by the flotation experiments using fine chalcopyrite (particle size D_{50} = 2.3 μm) with a varied amount of carrier particles of different sizes (–75 + 38 μm and –106 + 75 μm) using an agitated flotation cell. The addition of carrier particles improved the recovery of ultrafine particles into the froth from around 25% (without carrier) to around 80% (with 20 g of carrier, –75+38 μm size). Recovery of fine particles was higher with smaller carrier size (–75+38 μm) compared with larger carrier size (–106+75 μm), though the difference was not significant.
In Chapter 4, the effects of pyrite as a carrier for recovering finely ground chalcopyrite particles were investigated. Flotation experiments for finely ground chalcopyrite (D_{50} = 3 μm) were conducted with and without coarse pyrite (–125+106 μm) using potassium amyl xanthate as a collector. The results showed that untreated pyrite did not act as an effective carrier and that the amount of fine chalcopyrite attached to pyrite was not significant; furthermore, Cu recovery into froth was around 65% both with

and without pyrite. When pyrite was pre-treated with a $CuSO_4$ solution, its carrier ability improved owing to a significant amount of fine chalcopyrite becoming attached to the Cu^{2+}-activated pyrite particles and being recovered with pyrite into the froth (Cu recovery, >90 %).

In Chapter 5, a method to separate finely ground chalcopyrite particles from coarse pyrite particles was investigated. Results showed that at pH ~2, the collector adsorbed onto chalcopyrite/pyrite surfaces could be dissolved, and thus around 90% of fine chalcopyrite was detached from coarse pyrite particles.

In Chapter 6, a summary of this dissertation′s findings and implications were provided.