ABSTRAK

OPTIMASI PEROLEHAN TEMBAGA PADA PELINDIAN BIJIH SULFIDA KOMPLEKS MENGGUNAKAN OKSIDATOR *FERRIC SULFATE* ($Fe_2(SO_4)_3$) MELALUI METODE UJI KOLOM

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Bijih tembaga dari Pit Lerokis Zona 5, PT Batutua Tembaga Raya, didominasi mineral *chalcopyrite* ($CuFeS_2$) yang bersifat refraktori, sehingga menjadi kendala utama dalam proses pelindian suhu ruang. Menurunnya kandungan mineral sulfida sekunder (*chalcocite* (Cu_2S), *covellite* (CuS), *bornite* (Cu_5FeS_4)) yang lebih mudah larut semakin menekan perolehan tembaga. Penelitian ini bertujuan mengoptimalkan perolehan tembaga melalui penambahan *ferric sulfate* ($Fe_2(SO_4)_3$) sebagai oksidator, serta mengevaluasi pengaruhnya terhadap kondisi redoks, kinetika pelindian, dan perilaku logam pengotor pada uji kolom. Penelitian dilakukan dengan metode *column leaching* selama 32 hari menggunakan empat variasi: (1) tanpa oksidator (*baseline*), (2) *ferric sulfate* saat aglomerasi, (3) *ferric sulfate* dalam larutan pelindi, dan (4) kombinasi keduanya. Analisis meliputi *diagnostic leach*, titrasi, Atomic *Absorption Spectrophotometry* (AAS), serta pemantauan Eh-pH. Hasil menunjukkan kolom *baseline* hanya menghasilkan *recovery* tembaga (Cu) sebesar 11,9% dengan laju pelindian dikendalikan difusi ion melalui lapisan pasif sulfur dan Fe-sulfida. Penambahan *ferric sulfate* meningkatkan kondisi oksidatif (Eh ~0,36–0,40 V) dan mempercepat pelarutan sulfida sekunder. *Recovery* Cu meningkat menjadi 14,8% pada aglomerasi, 25,1% pada perlakuan larutan, dan mencapai 26,89% pada kombinasi keduanya. Besi (Fe) sebagian besar tetap berada dalam residu sebagai *pyrite*, sedangkan seng (Zn) lebih mudah larut hingga >15%. Analisis kinetika dengan *Shrinking Core Model* (SCM) menunjukkan bahwa mekanisme pengendali utama adalah difusi ion melalui lapisan produk ($R^2 > 0,99$), menegaskan sifat refraktori *chalcopyrite*. Secara keseluruhan, *ferric sulfate* terbukti efektif mengoptimalkan perolehan tembaga pada bijih sulfida kompleks, meskipun dominasi *chalcopyrite* masih memerlukan strategi lanjutan seperti pengendalian Eh-pH atau *bioleaching* untuk meningkatkan efisiensi pelindian.

Kata kunci: optimasi, pelindian tembaga, bijih sulfida kompleks, *ferric sulfate*, uji kolom, kinetika

ABSTRACT

OPTIMIZATION OF COPPER RECOVERY IN LEACHING OF COMPLEX SULFIDE ORE USING FERRIC SULFATE ($Fe_2(SO_4)_3$) *OXIDIZER THROUGH COLUMN TEST METHOD*

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Copper ore from Pit Lerokis Zone 5, PT Batutua Tembaga Raya, is dominated by chalcopyrite ($CuFeS_2$)*, a refractory mineral that presents a major challenge in atmospheric leaching. The decreasing proportion of secondary sulfide minerals (chalcocite* (Cu_2S)*, covellite* (CuS)*, bornite* (Cu_5FeS_4))*, which are relatively more soluble, further limits copper recovery. This study aims to optimize copper extraction by adding ferric sulfate* ($Fe_2(SO_4)_3$) *as a strong oxidant, and to evaluate its effects on redox conditions, leaching kinetics, and impurity behavior in column tests. The research was carried out using 32-day column leaching with four treatments: (1) no oxidant (baseline), (2) ferric sulfate addition during agglomeration, (3) ferric sulfate addition in the leaching solution, and (4) a combination of both. Analyses included diagnostic leaching, titration, Atomic Absorption Spectrophotometry (AAS), and monitoring of Eh–pH to assess system stability. The baseline column achieved only 11.9% Cu recovery, with the leaching rate controlled by ion diffusion through passive sulfur and Fe-sulfide layers. The addition of ferric sulfate improved oxidative conditions (Eh ~0.36–0.40 V) and accelerated secondary sulfide dissolution. Copper recovery increased to 14.8% in the agglomeration treatment, 25.1% in the solution treatment, and reached 26.89% in the combined treatment. Iron (Fe) mostly remained in the residue as pyrite, while zinc (Zn) dissolved more readily with recoveries above 15%. Kinetic analysis using the Shrinking Core Model indicated that the dominant mechanism was ion diffusion through product layers ($R^2 > 0.99$), highlighting the refractory nature of chalcopyrite. In conclusion, ferric sulfate proved effective in optimizing copper recovery from complex sulfide ores, although the dominance of chalcopyrite still requires further strategies, such as Eh–pH control or bioleaching, to achieve higher leaching efficiency.*

Keywords: optimization, copper leaching, complex sulfide ore, ferric sulfate, column test, kinetics