

Terak feronikel sebagai secondary resources cerium oksida, lanthanum oksida, magnesium oksida dan silika oksida melalui ekstraksi piro-hidrometalurgi = Ferronickel slag as secondary resources for precious minerals cerium oxide, lanthanum oxide, magnesium oxide and silica oxide through pyro-hydrometallurgical extraction method

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Abstrak

Terak Feronikel (TFN) merupakan produk sampingan yang dihasilkan dari proses peleburan nikel dengan metode pirometalurgi. Potensi TFN yang dimanfaatkan saat ini yaitu untuk konstruksi jalan, bahan campuran dalam industri semen dan aplikasi lain seperti pupuk, geopolimer dan teknik hidrolik. Namun demikian, proses keberlanjutan pemanfaatan TFN diperlukan karena produksi TFN meningkat sejalan dengan peningkatan permintaan nikel. Apalagi TFN merupakan bahan berbahaya dan beracun yang mampu mencemari tanah dan air tanah bila disimpan dalam waktu lama. Oleh karena itu, upaya peningkatan nilai tambah TFN perlu dilakukan untuk menekan akumulasi produk TFN. TFN mengandung sekitar 30% silika, 20% magnesium, 12% besi, 1-2% aluminium, dan serta nikel (Ni), kobalt (Co), kromium (Cr), dan unsur logam tanah jarang (LTJ). Berdasarkan kandungan yang ada di dalam TFN tersebut, proses ekstraksi unsur berharga menarik untuk dilakukan guna meningkatkan nilai tambah TFN.

Tujuan umum dari penelitian ini adalah memanfaatkan terak feronikel sebagai upaya peningkatan nilai tambah dengan mengekstraksi logam berharga dan logam tanah jarang terutama untuk lanthanum dan cerium dengan proses piro-hidrometalurgi. Tujuan khusus yang ingin dicapai dalam penelitian ini adalah untuk mengetahui analisis karakteristik TFN, studi pengaruh proses reduksi, studi pengaruh kalsinasi dan pelindian NaOH, studi pengaruh proses fusi alkali, pelindian air dan pelindian HCl, serta studi pengembangan proses ekstraksi logam berharga dari TFN.

Penelitian dilakukan dengan beberapa tahapan, bahan baku berupa TFN dikeringkan dalam oven, kemudian dilakukan reduksi ukuran menggunakan crusher dan disc mill. Bahan baku TFN dengan ukuran -200 mesh dicampur aditif Na₂CO₃ menggunakan mixer. Proses reduksi dilakukan dengan penambahan karbon dari batubara (BB) dan arang cangkang kelapa sawit (CKS) ditambah dengan zat aditif Na₂CO₃. Reduksi dilakukan dengan variasi temperature, rasio batubara atau arang cangkang kelapa sawit dan rasio Na₂CO₃. Proses kalsinasi dilakukan pada temperature 700°C selama 1 jam dilanjutkan dengan proses pelindian NaOH dengan variasi konsentrasi NaOH, temperatur dan waktu pelindian. Pelindian dengan NaOH ini dilakukan untuk memisahkan silika dengan magnesium. Silika yang terpisah dijadikan produk samping sebagai silika presipitat. Proses fusi alkali dengan penambahan aditif dilakukan dengan variasi temperatur. Pemanggangan dengan penambahan aditif diharapkan dapat mengikat silika yang merupakan unsur paling melimpah di TFN. Hasil pemanggangan fusi alkali kemudian dilindi dengan air. Residu yang dihasilkan dari pelindian air ini, kemudian dilindi menggunakan HCl. Sedangkan filtrat hasil pelindian air diendapkan dengan asam HCl encer secara titrasi untuk mendapatkan endapan silika presipitat. Analisis dilakukan dengan menggunakan X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF), Scanning Electron Microscopy (SEM) dan Inductively Coupled Plasma OES (ICP-OES).

Hasil penelitian ini menunjukkan bahwa proses reduksi menghasilkan fasa dominan yang terbentuk yaitu

sodium magnesiosilikat. Proses kalsinasi dilanjutkan NaOH menghasilkan persentase perolehan magnesium tertinggi adalah 73,10%, yang dihasilkan dari proses pelindian pada temperatur 100°C selama 240 menit dengan menggunakan NaOH 10M. Proses fusi alkali dengan penambahan zat aditif dapat mengikat silika yang merupakan unsur utama di TFN. Pelindian dengan air dari hasil fusi alkali dapat melarutkan silika dalam bentuk senyawa sodium silikat. Silika yang terlarut selanjutnya diendapkan dengan proses presipitasi untuk mendapatkan silika presipitat. Sedangkan residu hasil pelindian yang sudah mempunyai konsentrasi magnesium dan LTJ (lantanum dan cerium) dilakukan pelindian asam. Pelindian asam menggunakan larutan HCl dilakukan untuk mengekstrak kandungan magnesium dan LTJ (lanthanum dan cerium) yang terlarut dalam larutan filtrat. Hasil optimum ekstraksi magnesium dari pelindian asam menggunakan larutan HCl adalah 82,67 %. Kondisi optimum dicapai pada temperatur pelindian 80 °C, waktu pelindian 30 menit, konsentrasi HCl 2M, kecepatan pengadukan 300 rpm dan rasio S/L 1:10. Pada kondisi tersebut, studi kinetika magnesium menunjukkan bahwa proses pelindian magnesium pada TFN dipengaruhi oleh difusi. Kondisi pelindian optimum ekstraksi cerium dan lanthanum dicapai pada temperatur pelindian 80 °C, waktu pelindian 30 menit dan konsentrasi HCl 8 M dengan persentase ekstraksi optimum 92,63 % dan 86,82 %. Hasil studi kinetika menunjukkan nilai energi aktivasi 40 kJ/mol, sehingga difusi melalui lapisan abu akan mengontrol proses pelindian tersebut. Nilai energi aktivasi membuktikan bahwa pelindian cerium dan lanthanum dikendalikan oleh difusi melalui lapisan abu dari partikel padat dibandingkan dengan reaksi di permukaan partikel.

.....Ferronickel slag (FNS) is a by-product which was resulted from a nickel smelting process with a pyro-metallurgical method. The potential of TFN currently being utilized is for road construction, mixed materials in the cement industry, and other applications such as fertilizers, geopolymers, and hydraulic engineering. However, the sustainability process for FNS utilization is required due to increasing FNS production which is in line with increasing nickel demand. Moreover, FNS is a hazardous and toxic material that capable to pollute the soil and groundwater when it has been stored for long period. Therefore, attempts to upgrade the added value of FNS needs to be carried out to inhibit FNS accumulation. FNS contains 30% of silica, 20% of magnesium, 12% of iron, 1-2% of aluminum, and a small amount of nickel (Ni), cobalt (Co), chromium (Cr), and rare earth elements (REE). Based on the FNS content, the extraction process of valuable content is attractive to perform to upgrade the added value of FNS.

The general objective of this research is to utilize the ferronickel slag as an effort to upgrade the added value by extracting the rare earth metals, especially for lanthanum and cerium, using pyro-hydrometallurgy processes. The specific objectives to be achieved in this study were to determine the analysis of FNS characteristics, study the effect of the reduction process, study the effect of calcination and NaOH leaching, study the effect of the alkaline fusion process, water leaching, and HCl leaching, and study the development of the precious metal extraction process from FNS.

The research carried out in several stages, the raw material in the form of FNS was dried in an oven, then size reduction was carried out using a crusher and disc mill. FNS raw material with a size of -200 mesh is mixed with Na₂CO₃ additive using a mixer. The reduction process is carried out by adding carbon from coal and palm kernel shell charcoal plus the additive Na₂CO₃. The reduction is done by varying the temperature, the ratio of coal or oil palm charcoal, and the ratio of Na₂CO₃. The calcination process was carried out at a temperature of 700 ° C for 1 hour followed by a NaOH leaching process with variations in the concentration of NaOH, temperature, and leaching time. This NaOH leaching is carried out to separate the silica from magnesium. The separated silica is used as a byproduct as silica precipitates. Alkali fusion

process with the addition of additives is carried out with temperature variations. Roasting with the addition of additives is expected to bind Silica which is the most abundant element in the FNS. The roasting results are then leached with water. The residue resulting from the water leaching is then leached using HCl. Meanwhile, the filtrate from the water leaching was precipitated with dilute HCl acid by titration to obtain precipitated silica precipitates. Also, leaching is carried out using alkali NaOH. Analyzes were performed using X-Ray Diffraction (XRD), X-Ray Fluorescence (XRF), Scanning Electron Microscopy (SEM), and Induced Coupled Plasma OES (ICP-OES).

The results of this study indicate that the reduction process produces the dominant phase formed, namely sodium magnesiosilicate. The calcination process followed by NaOH resulted in the highest percentage of magnesium recovery, which was 73.10%, which was produced from the leaching process at 100 ° C for 240 minutes using 10M NaOH. The results of this study indicate that the alkali fusion process with the addition of additives can bind Silica as a major impurity element. Leaching with water can dissolve Silica in the form of sodium silicate which was resulted from alkali fusion. Dissolved silica can be used further as a material for Silica Precipitate, which can be obtained by precipitation. Meanwhile, the leaching residue is concentrated on valuable metals (magnesium) including rare earth elements (lanthanum, and cerium). Acid leaching using HCl solution was performed to calculate the upgrading content of dissolved magnesium, lanthanum, and cerium in the leached solution. The optimum result of magnesium extraction from acid leaching using HCl solution is 82.67%. The optimum condition reaches at leaching temperature of 80 °C, leaching time of 30 minutes, HCl concentration of 2 M, stirring speed of 300 rpm, and S/L ratio of 1/10. In that condition, Kinetics studies of magnesium show that the Magnesium leaching process of FNS was influenced by diffusion. The optimum leaching condition of cerium and lanthanum extractions reach at leaching temperature of 80 C, leaching time of 30 minutes, and HCl concentration of 8 M with optimum extraction percentage of 92.63% and 86, 82% respectively. The results of the kinetics study showed that the activation energy value was 40 kJ/mol, thus the diffusion through the ash layer would control the leaching process. The activation energy values prove that the release of cerium and lanthanum is controlled by diffusion through the ash layer of the solid particles compared to the reaction at the particle surface.