

Perilaku Reduksi Karbotermik Bauxite Residue dan Red Mud Menggunakan Reduktor Biomassa Cangkang Kelapa Sawit Segar = Carbothermic Reduction Behavior of Bauxite Residue and Red Mud Using Fresh Palm Kernel Shell Biomass as Reductant

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Abstrak

Limbah red mud dan bauxite residue hasil industri alumina mengandung oksida besi dalam jumlah signifikan, namun sering kali hanya menumpuk dan menimbulkan permasalahan lingkungan. Sementara itu, cangkang kelapa sawit segar (CKS) merupakan limbah biomassa lokal yang kaya karbon dan berpotensi dijadikan reduktor. Penelitian ini bertujuan memanfaatkan kedua jenis limbah tersebut guna memperoleh sumber logam besi sekunder. Sampel red mud dan bauxite residue dicampur dengan CKS berdasarkan rasio mol oksida terhadap karbon (1:0,5; 1:0,75; 1:1), kemudian dipeletisasi dan direduksi pada temperatur 1000 °C, 1100 °C, dan 1200 °C dalam atmosfer Argon selama 60 menit. Untuk memprediksi kestabilan fasa dan optimasi kondisi reduksi, dilakukan simulasi termodinamik menggunakan perangkat lunak HSC Chemistry 9.1.5. Derajat metalisasi Fe dihitung melalui titrasi dikromatometri sedangkan karakterisasi fasa dilakukan dengan XRD dan mikroskop optik. Hasil penelitian menunjukkan bahwa pada bauxite residue, terbentuk FeSiO dan AlSiO sebagai slag, serta pembentukan FeSi di temperatur reduksi 1100 °C dan 1200 °C. Sementara red mud cenderung membentuk slag FeAlO dan AlSiO. Pada pengamatan OM terlihat partikel logam yang semakin padat seiring kenaikan temperatur. Hasil EDS menunjukkan fasa terang pada bauxite residue berupa gabungan antara unsur Fe dan Si, sedangkan pada red mud hanya Fe. Didapat bahwa kondisi optimum tercapai pada temperatur 1200 °C dengan rasio O/C 1:1, yaitu derajat metalisasi Fe bauxite residue sebesar 68,31 % dan red mud sebesar 93,83 %.

.....Red mud and bauxite residue waste from the alumina industry contain significant amounts of iron oxides, yet they often accumulate and cause environmental problems. Meanwhile, fresh palm kernel shell (PKS) is a locally available biomass waste rich in carbon and has the potential to be used as a reductant. This study aims to utilize these two types of waste to obtain a secondary iron source. Samples of red mud and bauxite residue were mixed with PKS based on oxide-to-carbon molar ratios (1:0,5; 1:0,75; 1:1), then pelletized and reduced at temperatures of 1000 °C, 1100 °C, and 1200 °C in an Argon atmosphere for 60 minutes. To predict phase stability and optimize reduction conditions, thermodynamic simulations were performed using HSC Chemistry 9.1.5 software. The degree of iron metallization was calculated by dichromate titration, while phase characterization was carried out by XRD and optical microscopy (OM). The results of this study show that, in bauxite residue, FeSiO and AlSiO were formed as slag phases, with FeSi also observed at reduction temperatures of 1100 °C and 1200 °C. In contrast, red mud tended to form FeAlO and AlSiO as slag. Optical microscopy observations showed that metallic particles in both samples became increasingly dense with rising temperature. EDS analysis showed that the bright phases in bauxite residue consisted of a combination of Fe and Si, whereas in red mud, the bright phases were composed solely of Fe. The optimum condition was achieved at 1200 °C and an O/C ratio of 1:1, resulting in a metallization degree of 68.31% for iron in bauxite residue and 93.83% in red mud.