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Metal reduction by hydrogen from the B_2O_3-CaO-Ni(Zn,Pb,Cu)O melts thermodynamic modeling

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Abstract

Thermodynamic modeling is used to describe the metal reduction processes by hydrogen from oxide melt in the B_2O_3-CaO- MeO (Me – Ni, Zn, Pb, Cu) system. Open systems approximation with periodic removal of metal particles and gases from the working melt composition is used in the method. By this work we present the thermodynamic modeling results of metal reduction processes (Ni, Cu, Pb, Zn) by Hydrogen. The reducible metals oxides content in the all melts was 3 mass %, and the mass ratio of B_2O_3/CaO was taken as 3 to be close to eutectic composition. The calculations made it possible to determine such parameters as oxide melt compositions and elements reduction degree depending on the induced gas quantity. of the Nickel, Copper, Lead and Zinc reduction process simulation from B_2O_3-CaO-MeO melts proved the reduction process by Hydrogen is similar to that which was earlier established when Carbon monoxide was used as the reducing agent. When Copper is reduced from CuO, the process occurs with intermediate Cu_2O oxide formation (CuO → Cu_2O → Cu). The Nickel (NiO → Ni), Lead (PbO → Pb_s + Pb_g) and Zinc (ZnO → Zn_g) recovery have been realized by one stage. The non-ferrous metals change content in the oxide melt and the degrees of its reduction depending on temperature and reducing agent quantity introduced are described by the second-order polynomial functional equations. Comparison of the Carbon monoxide and Hydrogen used for Nickel, Copper, Lead, and Zinc reducing to 90% metallization degree proved much less Hydrogen consumption.

References

[1] N.A. Vatolin, G.K. Moiseev, B.G. Trusov. Thermodynamic modeling in high-temperature inorganic systems. *Moscow: Metallurgy.* **1994**. 352p. (russian)
[2] G.V. Belov, B.G. Trusov. Thermodynamic modeling of chemically reacting systems. *Moscow: MSTU named after N.E. Bauman.* **2013**. 96p. (russian)
[3] H.Y. Sohn. Process Modeling in Non-Ferrous Metallurgy. In: Treatise on Process Metallurgy: Industrial Processes (Ed. by S. Seetharaman). *Oxford: Elsevier Ltd.* **2014**. Chapter 2.4. P.701-838.
[4] A.A. Komkov, E.A. Ladygo, V.P. Bystrov. Thermodynamic analysis of the process of reductive depletion of slags rich in copper and nickel. *University News. Non-ferrous metallurgy.* **2002**. No.4. P.7-14. (russian)
[5] S.N. Tyushnyakov, and E.N. Selivanov. Thermodynamic simulation of zinc reduction from cooper-smelting slag. *Butlerov Communications.* **2015**. Vol.43. No.9. P.108-115. DOI: 10.37952/ROI-jbc-01/15-43-9-108
[6] C.A. Pickles, C.T. Harris, J. Peacey, J. Forster. Thermodynamic analysis of the Fe-Ni-Co-Mg-Si-O-H-S-C-Cl system for selective sulphidation of a nickeliferous limonitic laterite ore /Miner. *Eng.: An International Journal Devoted to Innovation and Developments in Mineral Processing and Extractive Metallurgy.* **2013**. Vol.54. P.52-62.
[7] N.K. Dosmukhamedov, E.E. Zholdasbay, G.B. Nurlan, Zh.B. Seitkulova. Investigation of the behavior of non-ferrous metals, iron, and arsenic during reductive depletion of copper-rich slags. *International Journal of Applied and Basic Research.* **2016**. No.1. Part 4. P.486-491. (russian)

[8] A.S. Vusikhis, L.I. Leontiyev, V.P. Chentsov, and E.N. Selivanov. Modeling of the gas reduction of metals process from multi-component oxide melt in the bubbled layer. *Butlerov Communications.* **2018**. Vol.55. No.7. P.58-63. DOI: 10.37952/ROI-jbc-01/18-55-7-58

[9] A.S. Vusikhis, L.I. Leontiev, E.N. Selivanov. Thermodynamic modeling of reduction of iron and nickel from melts of the B_2O_3-CaO-FeO-NiO system. *Proceedings of the Congress with International Participation and the Conference of Young Scientists "Fundamental research and applied development of processes for processing and utilization of technogenic formations." Ekaterinburg.* **2019**. P.312-316. (russian)

[10] A.S. Vusikhis, E.N. Selivanov, S.N. Tyushnyakov and V.P. Chentsov. Thermodynamic modeling of reduction of metals from B_2O_3-CaO-Ni (Zn, Pb, Cu) O melts carbon monoxide. *Butlerov Communications.* **2019**. Vol.59. No.9. P.125-131. DOI: 10.37952/ROI-jbc-01/19-59-9-125