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Aluminium interaction with multicomponent oxide system consisting of zirconium, titanium, silicon, iron

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Abstract

A theoretical and experimental study of the aluminum interaction with a multicomponent system containing oxides of zirconium, titanium, silicon, iron, niobium and rare earth elements is performed. The probability and sequence of metallic and oxide compounds formation was conducted with thermodynamic modeling method for the aluminothermic reduction of eudialyte concentrate. The results of the thermodynamic calculations revealed the influence of the temperature, consumption of the reducing agent and the additives in the charges of calcium and iron oxides on the metal reduction process, and were tested during the melting of the concentrate in the resistance furnace. According to the experimental results, the reduction of zirconium, titanium and niobium into the metal is about 70 wt. %. Rare earth elements and strontium after the reduction transferred (more than 90%) into oxide phase (slag), which can be further processed by known hydrometallurgical technologies. In the experiments, a fairly good separation of the metal and slag phases was achieved. To estimate the interfacial interaction, the surface tension and the density of the metallic and oxide phases were studied, which made it possible to evaluate the effect of these properties on the formation of the metal phase and, accordingly, the separation of metal and slag.

References

[1] S.A. Krasikov, A.L. Nadolskiy, A.A. Ponomarenko, O.A. Sitnikova, S.V. Zhidovinova. Metallothermic obtaining of titanium – aluminium alloys in a controlled temperature conditions. *Tsvetnye Metally.* **2012**. No.6. P.79-82. (russian)

[2] S.N. Agafonov, S.A. Krasikov, A.A. Ponomarenko, L.A. Ovchinnikova. Phase Relations in the Aluminothermic Reduction of ZrO_2. *Inorganic Materials.* **2012**. Vol.48. No.8. P.813-820.

[3] S.A. Krasikov, S.N. Agafonov, V.P. Chentsov, E.M. Zhilina. Influence of phase formation on the interphase interactions during the aluminothermic reduction of zirconium from its oxide. *Russian Metallurgy (Metally).* **2015**. Iss.8. P.615-618. (russian)

[4] A.G. Upolovnikova, and A.A. Babenco. Thermodynamic modeling of boron recovery from boron-containing slag. *Butlerov Communications.* **2016**. Vol.48. No.10. P.114-118. DOI: 10.37952/ROI-jbc-01/16-48-10-114

[5] A.A. Babenco, L.A. Smirnov, V.I. Zhuchkov, A.V. Sychev, and A.G. Upolovnikova. Using of simplex lattices method for diagramming composition-viscosity of the slag system $CaO-SiO_2-Al_2O_3-MgO-B_2O_3$. *Butlerov Communications.* **2016**. Vol.48. No.11. P.40-44. DOI: 10.37952/ROI-jbc-01/16-48-11-40

[6] E.M. Zhilina, S.A. Krasikov, S.N. Agafonov, L.B. Vedmid, and S.V. Zhidovinova. Thermodynamic and kinetic peculiarities of joint aluminothermic reduction of titanium and zirconium from oxides. *Butlerov Communications.* **2016**. Vol.45. No.1. P.130-135. DOI: 10.37952/ROI-jbc-01/16-45-1-130

[7] S.A. Krasikov, A.G. Upolovnikova, O.A. Sitnikova, A.A. Ponomarenko, S.N. Agafonov, S.V. Zhidovinova, D.V**.** Mayorov. Phase formation during the carbothermic reduction of eudialyte concentrate. *Russian Metallurgy (Metally)*. **2013**. Iss.7. P.482-485. (russian)

[8] S.A. Krasikov, A.G. Upolovnikova, S.N. Agafonov, S.V. Zhidovinova, V.A. Matveev. Behaviour of elements during the aluminothermic reduction of eudialyte concentrate. *Tsvetnye Metally.* **2013**. No.12. P.62-66. (russian)

[9] S. Krasikov, E. Zhilina, S. Agafonov, V. Chentsov, A. Postnikova. Influence of the Physical – Chemical Parameters on the Aluminothermic Reduction of Eudialyte Concentrate. Proceedings of 46th International October Conference on Mining and Metallurgy, 01-04 October **2014**, Bor Lake, Serbia. P.116-119.
[10] S.A. Krasikov, V.A. Matveev, D.V. Mayorov, E.M. Zhilina, S.N. Agafonov. Prospect of combination hydro- and pyrochemical methods at the processing eudialyte concentrates. *Transactions of Cola Science Centre of Russian Academy of Scienc*es. Apatity. **2015**. No.5. P.73-75. (russian)
[11] A. Roine. Outokumpu HSC Chemistry for Windows. Chemical Reaction and Equilibrium Software with Extensive Thermochemical Database. *Pori: Outokumpu Research OY*. **2006**. 448p.
[12] G.K. Moiseev, N.A. Vatolin. Some patterns of change and methods for calculating the thermochemical properties of inorganic compounds. *Ekaterinburg: UB RAS*. **2001**. 137p. (russian)
[13] S.I. Popel. Theory of metallurgical processes. *Moscow: VINITI*. **1971**. 132p. (russian)
[14] M.I. Gasik, M.P. Lyakishev, B.I. Emlin. Theory and technology of ferroalloys production. *Moscow: Metallurgy*. **1988**. 784p. (russian)
[15] V.N. Lebedev, and A.V. Rudenko. Isolation of rare-earth elements in the hydrochloric acid decomposition of eudialyte. *Chemical Technology*. **2003**. No.1. P.26-29. (russian)
[16] V.N. Lebedev. Sulfuric acid technology of eudialyte concentrate. *Russian Journal of Applied Chemistry*. **2003**. Vol.76. Iss.10. P.1559-1603. (russian)
[17] V.I. Zakharov, G.S. Skiba, A.S. Soloviev, V.N. Lebedev, D.V. Mayorov. Some aspects of acid treatment of eudialyte. *Tsvetnye Metally*. **2011**. No.11. P.25-29. (russian)
[18] V.I. Zakharov, D.V. Mayorov, A.R. Alishkin, V.A. Matveev. Causes of insufficient recovery of zirconium during acidic processing of lovozero eudialyte concentrate. *Russian Journal of Non-Ferrous Metals*. **2011**. Vol.52. No.5. P.423-428. (russian)