Full Paper ____ *Thematic Section:* Thermodynamic Research.
The Reference Object Identifier – ROI: jbc-01/20-62-4-94 *Subsection:* Technology of the Inorganic Substances.
The Digital Object Identifier – DOI: 10.37952/ROI-jbc-01/20-62-4-94
Submitted on April 29, 2020.

Modeling of metals reducing from B_2O_3-CaO-Fe_2O_3-ZnO melts by CO-CO_2 mixtures

© **Alexander S. Vusikhis**,+ **Evgeny N. Selivanov**,*
Stanislav N. Tyushnyakov, and **Victor P. Chentsov**
Institute of Metallurgy. Ural Branch of RAS. Amundsen St., 101. Yekaterinburg, 620016. Russia.
E-mail: vas58@mail.ru

*Supervising author; +Corresponding author

Keywords: methodology, thermodynamic modeling, kinetics, reducing, gas, bubbling, multi-component oxide melt, metal.

Abstract

Thermodynamic modeling technique has been developed to predict the conditions of metals reduction from oxide melt by gas during bubbling processes. The technique provides approximation to real systems with periodic removal of metal phase and gases from the working body. The given work presents thermodynamic modeling results of Zinc and Iron reduction processes from B_2O_3-CaO-Fe_2O_3-ZnO melts by CO-CO_2 different composition mixtures in the 1273-1673 K temperature range. Approximation to real processes is used. Zinc and Iron oxides content in the melt and its reducing degree have been estimated during the calculations.

Three stages of the process have been obtained by the calculations. Reducing of Fe_2O_3 to Fe_3O_4 and FeO is realized in the first stage. Concentration of Fe_2O_3 (C_{Fe2O3}) decreases almost to zero while C_{Fe3O4} и C_{FeO} have been increased simultaneously. Concentration of C_{Fe3O4} reaches its maximum to the end of process. Transition of $Fe_3O_4 \rightarrow$ FeO takes place in second stage when C_{FeO} reaches its maximum, and Zinc and Fe begin its reducing. Temperature increase promotes metallization by Zinc, but decreases by Iron. An increase of input gas CO/CO_2 ratio leads to Fe reducing degree. It thereby ensures required indicators of the Zinc selective reduction achievement but requires more gas consumption.

The relationships between C_{ZnO} and φ_{Zn} depending on temperature and amount of reducing input gas consumption have been obtained. Given work results may be useful for precut estimation of the probable parameters of Zinc distillation process from the melt. Besides, these results may be useful as the basis for the experimental results analysis.

References

[1] E.N. Selivanov, V.A. Bryukvin. Estimation of Zinc-containing waste scale formation in non-ferrous metallurgy in Russia. Proc. Int. Congress. «Fundamentals of processing technologies and industrial wastes utilizing». *Yekaterinburg*: *UIPTS*. **2012**. P.56-61. (russian)
[2] L.I. Leontyev, V.G. Dyubanov. Technogenic wastes of ferrous and non-ferrous metallurgy and environment problems. *Ecology and industry of Russia*. **2011**. No.4. P.32-35. (russian)
[3] A.I. Okunev, I.A. Kostyanovsky, P.A. Donchenko. Fumigation of slag. *Moscow: Metallurgy.* **1966**. P.259. (russian)
[4] Yu.I. Sannikov, M.A. Lyamina, V.A. Shumsky. Influence of the slag melt composition to reducing mechanism of ZnO. *Izv. AS USSR, Metals.* **1987**. No.5. P.60-65. (russian)
[5] V.G. Leontiev, V.A. Bryukvin, E.Ya. Gurevich. Intensification physicochemical fundamentals of the slag melts carbothermic reduction. *Non-ferrous metals*. **1995**. No.10. P.32-34. (russian)
[6] V.V. Kozyrev. Distillation of Zinc from slag during fumigation by natural gas. *Non-ferrous metals.* **2009**. No.2. P.61-64. (russian)
[7] A.V. Tarasov, A.D. Besser, V.I. Maltsev. Metallurgical processing of secondary Zinc raw materials. *Moscow: Gintsvetmet.* **2004**. P.219. (russian)
[8] A.S. Kolesnikov. Thermodynamic modeling of the Silicon, Iron reduction and distillation of Zinc, Lead in Zinc-oligonite ore − Carbon systems. *University News. Non-ferrous metallurgy.* **2014**. No.5. P.11-15. (russian)
[9] V.M. Chumarev, E.N. Selivanov. Gas phase role in the reduction kinetics of Zinc and Iron from slag melts by Carbon. *Metals.* **2013**. No.2. P.28. (russian)

[10] Tyushnyakov S.N., Selivanov E.N., Chumarev V.M. Estimation of the Zinc sublimation rate from slag in direct current furnace. *Non-ferrous metals*. **2013**. No.12(852). P.13-17. (russian)
[11] V.G. Leontiev, V.A. Bryukvin. Rduction of slag melts in foaming mode. *Non-ferrous metals*. **2012**. No.12. P.48-50. (russian)
[12] M.H. Morcali, O. Yucel, A. Aydin, B. Derin. Carbothermic reduction of electric arc furnace dust and calcination of waelz oxide by semi-Pilot scale rotary furnace. *Journal of Mining and Metallurgy, Sect. B-Metall.* **2012**. Vol.48. No.2. P.173B -184A.
[13] H.N. Zhang, J.L. Li, A.J. Xu, Q.X. Yang, D.F. He, N.Y. Tian, Carbothermic reduction of zinc and iron oxides in electric arc furnace dust. *J. Iron Steel Res. Int.* **2014**. Vol.21. P.427-432.
[14] N.A. Vatolin, G.K. Moiseev, B.G. Trusov. Thermodynamic modeling in high-temperature inorganic systems. *Moscow: Metallurgy.* **1994**. P.352. (russian)
[15] G.V. Belov, B.G. Trusov. Thermodynamic modeling of chemically reacting systems. Moscow: *MSTU named after N.E. Bauman.* **2013**. P.96. (russian)
[16] 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. https://doi.org/10.37952/ROI-jbc-02/18-55-7-58