CALPHAD-based thermodynamic evaluation for integrating secondary Ni-containing dusts in ferrous processing.

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Abstract

The present work demonstrates the use of FactSage software [1] to thermodynamically assess the integration of secondary Ni dusts in ferrous processing. Integrating alternative material streams into conventional or new metallurgical processes provides significant advantages in terms of resource efficiency. Yet, it requires a comprehensive analysis in terms of interactions, chemical reactions, effect of the process parameters on the equilibrium conditions and final products, and monitoring of impure elements. With the use of simulation tools, the mentioned aspects can be analyzed thus providing suggestions for the subsequent experimental conditions in optimized areas. The Ni dusts are sourced from a Greek ferronickel plant, and it is suggested to upcycle them into a smelting treatment to recover iron alloy and slag products. The dusts are sourced from two different furnaces of the process line, which are the Rotary Kiln (RK) and the Oxygen Converter (CONV). Thus, their chemical and physical properties are examined. The RK dust contains mainly SiO_2 (36.9 wt.%), Fe_{total} (17.9%), and NiO (1.3 wt.%), Al_2O_3 (7 wt.%), and MgO (10 wt.%). The CONV dust is rich in Fe_{total} (48.1 wt.%), NiO (8.8 wt.%), SiO_2 (1.5 wt.%), Al_2O_3 (4.2 wt.%), and MgO (3.5wt.%). The work seeks to increase the understanding of the properties of the dusts which will affect the suggested treatment options. The main goals are to optimize feed material compositions, reinforce the understanding of process chemistry, support the experimental design considering further utilization potential of the final products. The process parameters, such as the Fe/Ni ratio in the feed mixture, temperature, and slag composition, have been optimized. It was seen that the grade of the final alloy is independent of the Fe/Ni ratio of the feed mixture. However, the feed composition influences the C and Si content of the obtained alloy, in agreement with other studies [2], [3]. The characteristics of the slag are simulated and assessed in terms of chemistry, slag/metal equilibria, and liquidus temperature. The slag chemistry consists mainly of FeO-MgO-SiO_2, and it was seen that FeO reduces the liquidus temperature of the slag, whereas it decreases at increased SiO_2/MgO (*wt.%/wt.%*) ratios [4]. Implementing the process at high temperatures (higher than 1500^oC) can be beneficial in terms of fully liquid alloy and slag, separation of products, and thus operational requirements. According to the obtained results, a high-grade FeNi alloy and slag with the prospect to be utilized in the ceramic industry are thermodynamically outlined.

References

[1] C. W. Bale *et al.*, “FactSage thermochemical software and databases, 2010-2016,” *Calphad: Computer Coupling of Phase Diagrams and Thermochemistry*, vol. 54, pp. 35–53, Sep. 2016, doi: 10.1016/j.calphad.2016.05.002.

[2] D. R. Swinbourne, “Understanding ferronickel smelting from laterites through computational thermodynamics modelling,” *Mineral Processing and Extractive Metallurgy*, vol. 123, no. 3, pp. 127–140, Sep. 2014, doi: 10.1179/1743285514Y.0000000056.

[3] D.-H. Kim, S.-Y. Won, J.-S. Han, H.-S. Nam, and J.-J. Pak, “Thermodynamics of Sulfur in Carbon Saturated Liquid Ferro-alloys Containing Ni, Mo and V at 1873 K,” *ISIJ International*, vol. 58, no. 3, pp. 408–414, 2018, doi: 10.2355/isijinternational.ISIJINT-2017-509.

[4] B. Zhao, E. Jak, and P. C. Hayes, “The effect of MgO on liquidus temperatures of fayalite slags,” *Metall Mater Trans B*, vol. 30, no. 6, pp. 1017–1026, Dec. 1999, doi: 10.1007/s11663-999-0107-5.