

## Thermodynamic modeling of the joint processing of oxidized nickel ores and sulfide copper-bearing ores

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**Keywords:** ore, nickel, copper, sulfur, thermodynamic modeling, heating, oxidation, reduction, sulfidation, equilibrium composition, oxides, sulfides, matte, slag.

### Abstract

In order to improve the comprehensive utilization of mineral raw materials the option of co-processing of oxidized nickel ores and copper-bearing sulfide ores in a blast furnace or electric furnace is offered. The use of partially oxidized sulfide copper ore as a sulfidizer allows for adjusting the composition of slag and matte; furthermore, it provides environmental advantages in terms of the reducing of sulfur dioxide emissions. Thermodynamic modeling of the equilibrium compositions of phases during the joint high-temperature heating of oxidized nickel ore and copper-bearing sulfide ore allows for predicting the parameters of the process. Calculation of the equilibrium amounts and phase compositions formed by heating up to 1300 °C of the working medium composed of oxidized nickel ore, roasted copper sulfide ore and calcium oxide was made at a weight ratio of 1 : 0.6 : 0.1. It was shown that non-ferrous metals (copper, nickel and cobalt) were concentrated in sulfide and metallic phases. The additive of reductant (carbon) into the working medium allowed for adjusting the metallization degree of mattes and recovery of target components. The best of the results were achieved by adding of 3.1% of carbon by weight of oxidized nickel ore into the working medium. In the run, fusible iron-magnesium-silicate slag and matte contained 15-20% of non-ferrous metals and about 20% of sulfur was formed. Furthermore, carbon addition would greatly reduce the sulfur emission into the gas phase by heating of charge.

According to the simulation results it was shown that the option technologically justified was co-processing (1300 °C) of oxidized nickel ore, partially oxidized sulfide copper ore (desulfurization degree is about 70-85%), calcium oxide and carbon, taken in a weight ratio of 1 : 0.6 : 0.1 : (0.01-0.03). Matte as a product formed by sulfide and metallic phases has fully corresponded with the composition of nickel matte of the existing plants. The matte was comprised of, % wt.: 51.6-69.2 Fe, 20.9-30.4 S, 5.1-8.0 Ni, 3.4-5.5 Cu, 0.7-0.9 Co, 0.7-2.4 Zn, 0.07-0.08 Pb and 0.004-0.016 As. Its weight was from 8 to 13% by weight of the initial charge. The ores components have extracted into the matte in such degrees, %: 94.7-99.3 Ni, over 99.9 Cu, 60.5-94.9 Co, 23.3-41.7 Zn, 15.7-24.7 Pb and 3.3-8.9 As. Enrichment degree of the matte relative to the original working medium was 7.7-11.8 for nickel, 7.8-12.5 for copper, and 7.5-9.8 for cobalt; metallization degree of the matte was equal to 14.7-53.5%. Desulfurization degree by heating and melting of the charge was 2.7-11.9%. Slag (sum of oxide phases) have satisfied the requirements of nickel production, its composition have varied in the following range, % wt.: 53.0-57.4 SiO<sub>2</sub>, 13.1-14.3 MgO, 7.3-7.9 CaO, 3.4-3.9 Al<sub>2</sub>O<sub>3</sub>, 14.2-18.9 Fe, less than 0.01 Ni and Cu, 0.005-0.060 Co, 0.02-0.09 Zn, less than 0.001 As, Pb and Sb. Its weight was equal to 79.7-87.1% of the charge. Components recovery into the slag was, %: 0.8-5.3 Ni, less than 0.01 Cu, 4.5-30.0 Co, 5.1-20.0 Zn, 2.4-8.9 As and less than 0.001 Sb. Basicity of the slag was equal to 0.63-0.76. Values of conditional equilibrium constants of exchange reactions between the matte and slag were 0.006-0.014 for nickel, 0.037-0.096 for cobalt.

The data obtained is expedient to use for a substantiation of the technology of the joint complex treating of oxidized nickel ores and copper-bearing sulfide ores.

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