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Thermodynamic analysis of separating synchronously copper and iron components from copper smelting slags

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Abstract

The occurrence state changes and the possibility of synchronous separation of the components with copper and iron were researched by detailed calculation and derived, from the thermodynamics point of view in the oxidation modification process of copper smelting slag. The relationship between oxygen and sulfur potential of coexistence stage for metallic copper and the magnetite was concluded by analyzed the advantage area chart of Cu−Fe−S−O system. The Thermodynamic studies show that, there was a stability range of the oxygen and sulfur potential in Cu−Fe−S−O system, which made the metallic copper and the magnetite coexistence. The research will provide theoretical support for the synchronous separation between copper and iron components from copper smelting slag.

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Keywords: Thermodynamic analysis; separating synchronously; oxygen potential; sulfur potential

1. Introduction

In recent years, the production of refined copper is increasing significantly in China, the production was 4.25 million tons in 2009, and it reached to 7.67 million tons in 2014, and more than 15 million tons of copper smelting

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slags were produced every year. The content of iron is about 40wt% in the slags, which is much higher than the 27wt% recoverable ore grade, and that of copper is from 0.2wt% to 5wt%, and there are other valuable metals, such as nickel, cobalt and molybdenum, et al [1, 2]. At present, the utilization ratio of copper is below 12wt%, and that of iron is below 1wt% in copper smelting slags. The slags have become the negative factor of hindrance sustainable development of copper smelting enterprise, because that most of the slags were discarded at slag yard, which not only occupancy soil but pollute environment, it is also enormous waste. It has a positive role to alleviate the pressure of iron and copper concentrate ore resources to realize the valuable components of efficient recycling copper slag.

Though recovery valuable constituents from copper smelting slags were extensive researched, the separation effect is not sufficient because of using raw slag as studied object [3, 4], it is difficult to recovery the iron constituents in raw slag by means of traditional separation technology because of the iron constituents mainly existed as fatality (Fe_2SiO_4) and fine mineral dissemination, and small grain size. The smelting reduction technology for extracting iron was studied by Li Lei, and the reduction reaction thermodynamics theory of each element was researched [5]. The selective chloridizing roasting treatment was applied in disposing copper slag by Ren-jie zhang, the copper chloride was obtained through the method of chloride volatile, but the iron components such as magnetite and fayalite were not chloride, and the thermodynamics analysis was studied in detail [6]. High temperature melt oxidation−room temperature crushing magnetic separation method was adopted by Lin-nan zhan, but the research did not account for recycling copper components in the process [7−9].

The high temperature melt oxidation was researched to realize the selective and synchronize enrichment copper and iron components in this paper, by controlling the oxygen and sulfur potential in reaction process, and the thermodynamics of oxidation reaction was researched to clear the effects of oxygen potential on the synchronous enrichment.

2. Experimental

The chemical components of some converter slag were showed in Table 1, it is difficult to synchronously recover the valuable components from the raw slag, because they were distributed in many minerals, such copper matte, metallic copper, chalcopyrite, cuprites, pyrite, magnetite, fayality, hematite, et al.

Table 1. Mineral composition of copper smelting slag

Component	Copper matte	Magnetite	Copper	Hematite	Iron	Fayalite	Silicate	Feldspar	Others
Content (%,ω)	5.2	26.8	0.9	2.5	0.5	47.3	11.7	2.5	2.6

3. Thermodynamic analysis of separating synchronously copper and iron components

3.1 Thermodynamic analysis of major reactions

The major occurrence statue of copper and iron component in raw slag was copper matte, which was the eutectic of cuprous sulfide and ferrous fulfide in slag, the following reactions will happen under the oxidizing atmosphere as equation 1 to 7. The reaction of generating metal between sulfide and oxidant will be determined by the relationship between ΔG° and T of sulfide and oxidant. From fig.1, we can know that, the oxidation reaction of ferrous fulfide will happen firstly, then the reaction of generating metallic copper will proceed when the ferrous fulfide was oxidized completely, when the ferrous fulfide was concurrent synchronously with cuprous sulfide;

$$FeS(l) + 2FeO(l) = 3Fe(l) + SO_2(g)$$
$$\Delta rG^{\Theta} = 255864 - 69.32T(J/mol) \quad (1)$$

$$Cu_2S(l) + 2Cu_2O(l) = 6Cu(l) + SO_2(g)$$
$$\Delta rG^{\Theta} = 35982 - 58.87T(J/mol) \quad (2)$$