Fayalite Based Slags: Metal Recovery and Utilization

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Abstract

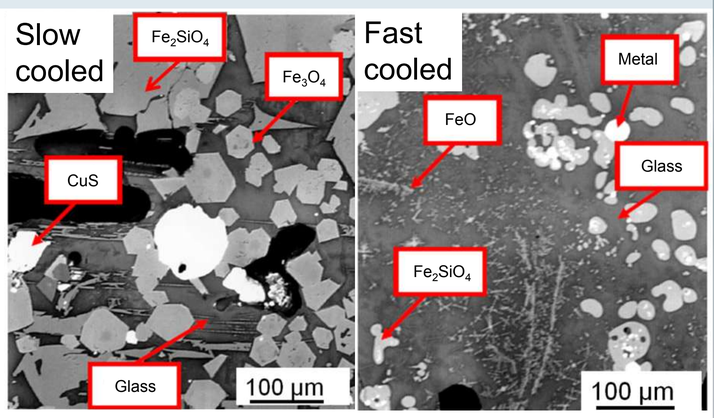
Fayalite based slag has already been used for a long time in copper metallurgy. The production of copper from both ores and secondary resources results in major amounts of fayalite slag at a rate of 2.2 ton slag per ton of produced copper. Fayalite slag still contains valuable metals in concentrations sometimes exceeding the content of current natural ores. Rather than being a waste, the slag residue itself can be used in different applications. In order to utilize fayalite based slag and improve the sustainability of the copper metallurgical process, new extraction techniques and slag applications need to be implemented or developed.

Although fayalite is the main phase, the resulting microstructure and metals content of the slag slightly differs depending on the metallurgical process and the cooling practice. Applicable techniques for metal recovery and slag utilization depend on the final microstructure of the slag. This paper reviews existing and novel routes for metal recovery and fayalite slag utilization.

Keywords: slags, fayalite, microstructure, non-ferrous metals recovery, utilization, leaching

Chemical and Mineralogical Compositions

The main constituents of a copper slag are FeO and SiO_2, each present at about 20-55 wt%. The copper content of a smelter slag is normally around 1 wt% while converter slag contains in general much more Cu (2~25 wt%), which is much higher than that of copper ore (0.5~1 wt%), due to overoxidation and entrapment of metal droplets. Some Cu slags also contain Co and/or Ni at levels of interest for recovery. Toxic elements (e.g. As) and heavy metals (e.g. Pb) exist in some copper slags as well. The mineralogical compositions of slags generated from different origin are quite diverse due to many factors such as ore types, processing techniques and cooling rates. Normally, fayalite and magnetite are the two dominant phases. Ni and Co are present in the form of oxides while Cu in the form of oxides, metallic copper and various copper sulphides has been identified.



Metal Recovery

❖ **Mineral processing**

By applying mineral processing technologies, such as crushing, grinding, magnetic separation and flotation, followed by hydro- and/or pyrometallurgical processes, it is possible to recover metals such as Fe, Cr, Cu, Al, Pb, Zn, Co, Ni, Nb, Ta, Au, Ag etc. from the slags.

❖ **Pyrometallurgy**

According to the differences in the process conditions and reduction rates, recovery of different metals in a multiple-stage process.

❖ **Pyro-hydrometallurgy**

Pyro-hydrometallurgical recovery of metal from fayalite slags normally consists of two steps: roasting and leaching. The principle of roasting is to convert the metals in a slag into a desired form which can be separated from the slag.

❖ **Hydrometallurgy**

The essential characteristic of hydrometallurgy is to dissolve the metals in liquids and then process them in subsequent solvent extraction and/or electrowinning operations.

Utilization

❖ **Cement**

Utilization of slag in cement and concrete production is one of the greatest potential outlets of fayalite slags. Applying fayalite slag as partial replacement of cement (up to 40 %) not only reduces the energy consumption and CO_2 output of cement making (only grinding is needed) but also beneficially recycles the by-product.

❖ **Aggregate**

Fayalite slags have similar properties to those of natural basalt (crystalline) or obsidian (amorphous). Using fayalite slag as aggregates is an application with large volume throughputs which will save space of piling up the slag and produces an economical benefit at the same time.

❖ **Abrasive tool**

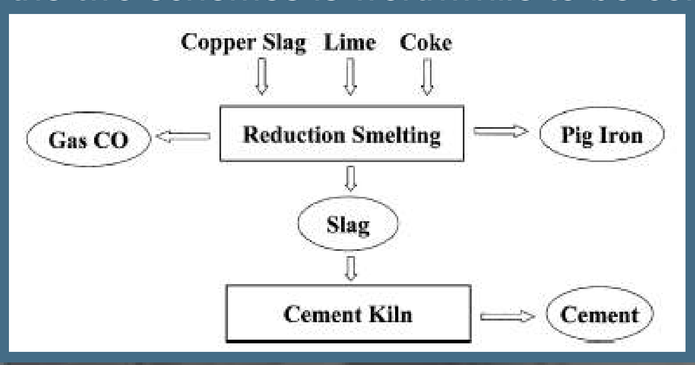
Copper slag is widely used as an abrasive media to remove rust, old coating and other impurities in dry abrasive blasting due to its high hardness (6-7 Mohs), high density (2.8-3.8 g/cm^3) and low free silica content.

❖ **Other utilizations:**

- **Tile and pavement**
- **Glass ceramics**
- **Wastewater treatment**

Combined Schemes

In order to achieve full valorization of the slag, the combination of the two schemes is worthwhile to be considered.



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