Copper Smelting Slideshow

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What is copper smelting?

The method of extracting pure elemental copper (Cu) from copper concentrate ($CuFeS_2$).

Smelting Furnace

Smelting is carried out in a structure called a *smelting furnace*. For small scale refining, these may be small vessels, but at major smelting operations the furnace may be several (6-7) stories high.

Refractory Bricks

The structure housing the furnace may be made of steel, but the furnace itself is made of *refractory brick.* Refractory bricks are made from clays with super high melting temperatures and insulating properties that make them perfect for use in furnaces holding molten minerals because they do not melt and interfere with the chemistry of the metals.

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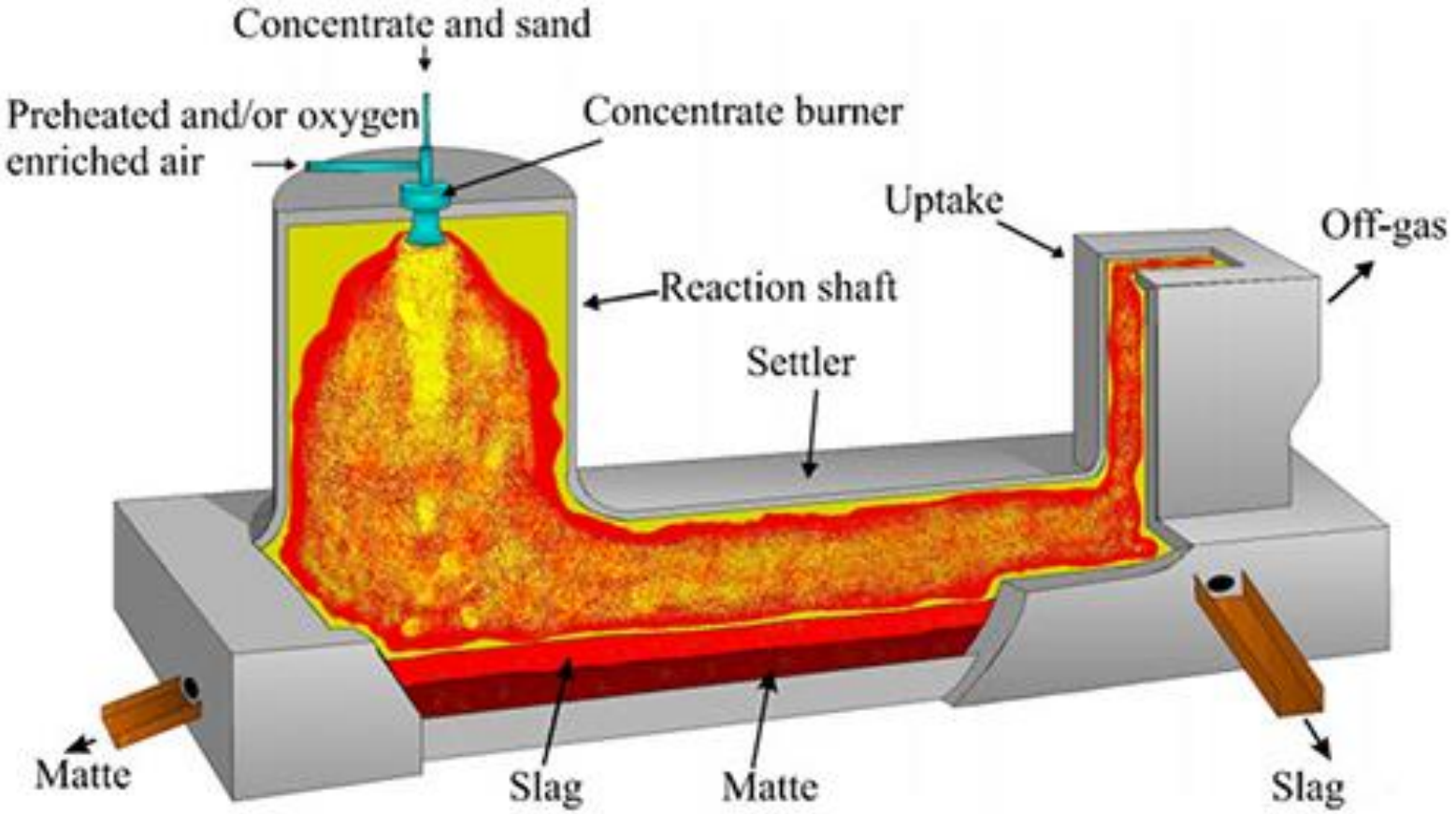
Copper Concentrate

Copper concentrate ($CuFeS_2$) is fed into the furnace along with a *flux* of silica sand, SiO_2, and oxygen, O_2. The flux is used to control the chemistry of the slag. In particular, it causes the iron (Fe) in the copper concentrate to accumulate in the slag phase, while the copper (Cu), accumulates in the *matte* phase.



Fueling the Furnace

The furnace is ignited with a natural gas flame, but it's continuously fueled by the *sulphur* (S_2) in the copper concentrate. The sulphur combines with the added oxygen (O_2) to form *sulphur dioxide gas* (SO_2). The sulphur dioxide gas is captured and used to make sulphuric acid (H_2SO_4), which is used in many applications.

Copper concentrate ($CuFeS_2$) **Oxygen (O_2)** **Flux (SiO_2)**

$$10CuFeS_2 + 15½O_2 + 3½SiO_2 \Rightarrow$$

$$5Cu_2S + 3FeS \text{ (matte)}$$

$$+ 3½Fe_2SiO_4 \text{ (slag)}$$

$$+ 12SO_2 \text{ (sulphur dioxide)}$$

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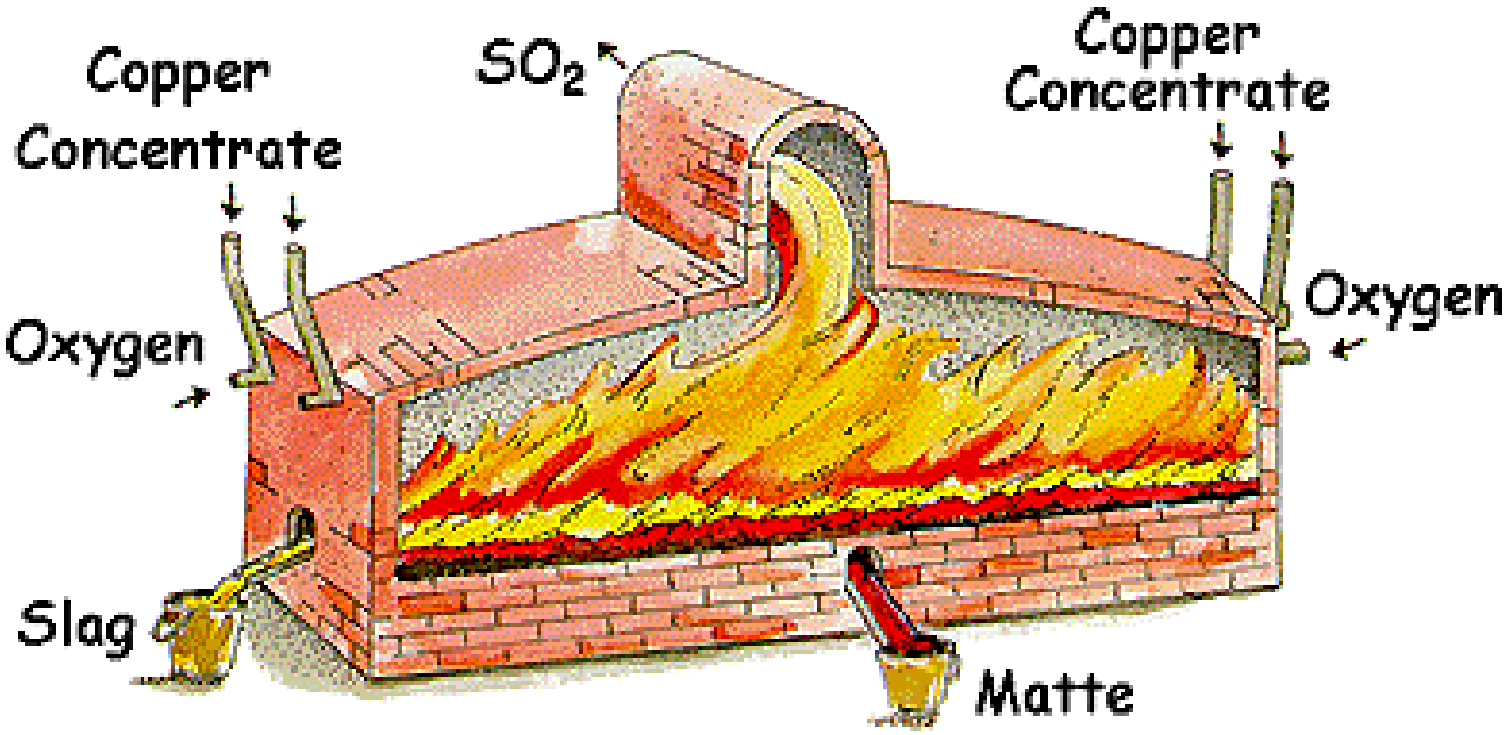
Smelted Minerals

The smelted minerals accumulate in the bottom of the furnace in two layers: the slag on top, and the copper-bearing matte on the bottom. The slag and matte are tapped off through portals in the wall of the furnace. The matte, which may be up to 70% copper is then fed to a converter.



Converting

In the *converter*, coal is added to the *matte* to change the chemistry and help accumulate any remaining impurities like iron (Fe) and quartz (SiO_2) in the slag phase. Again sulphur dioxide gas is captured for further use. The converter treatment produces a copper metal-rich melt called *blister copper*.

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Slag

Slag from the smelting process can contain up to 20% copper. It's allowed to cool and then reused in the smelting furnace to control the temperature, or it's treated by grinding and flotation and fed back into the smelting process to recover additional copper.

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Blister Copper

Blister copper is only 90% pure copper. This is not pure enough to be used in manufacturing. The blister copper is cast into shapes called anodes, and the anodes are sent to a refinery for final purification.

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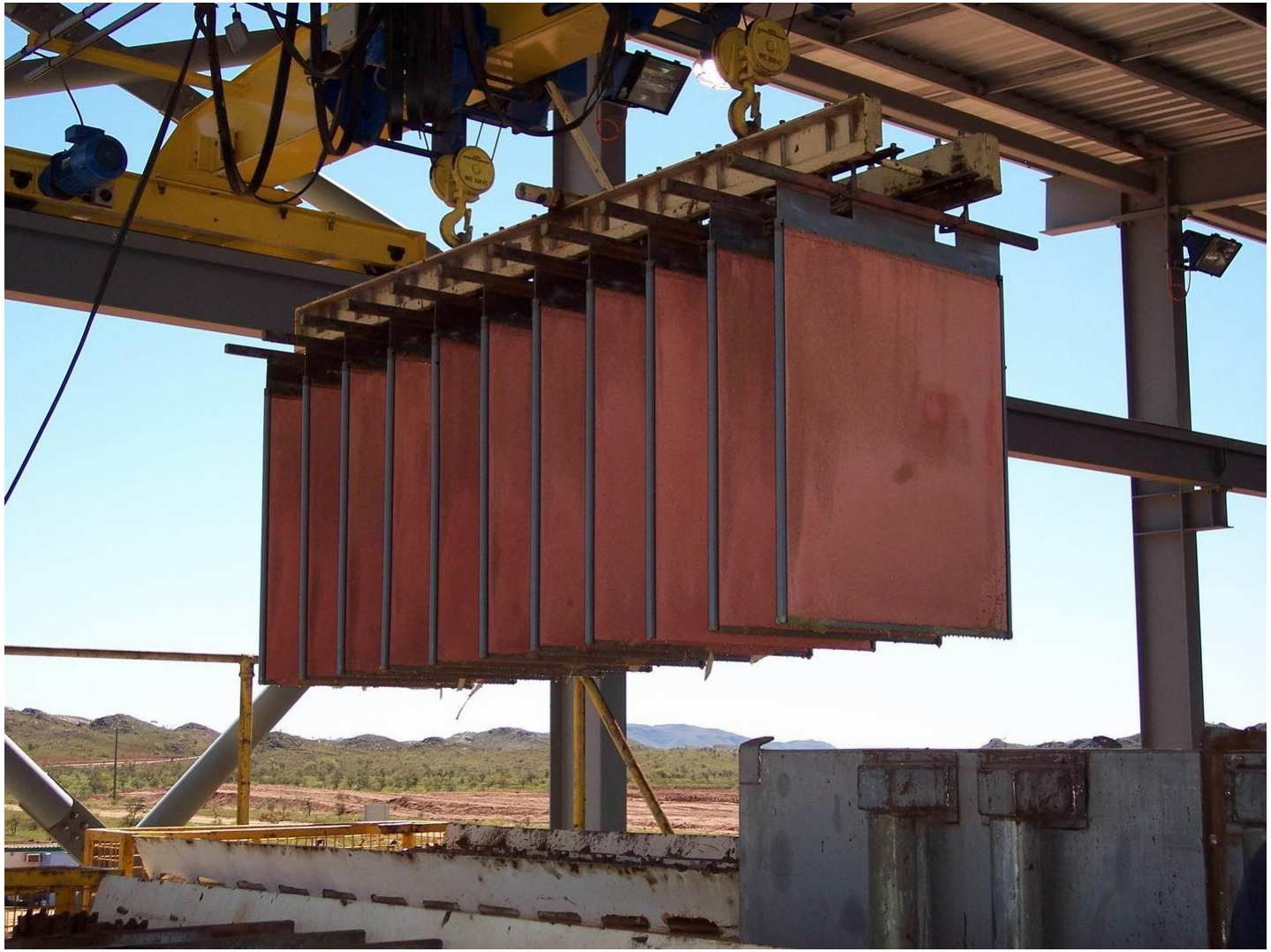
Electrorefining

The final step in purification is called *electrorefining*. The copper anodes are placed in a large electrochemical cell alongside steel cathodes and bathed in *sulphuric acid* (H_2SO_4). An electric current is passed through the cell and Cu^{2+} ions from the anode dissolve into the acid and transfer onto the steel cathodes. The impurities in the copper anodes, such as gold or silver, settle to the bottom of the tank as sludge.

Cathode Copper

The anode may take up to three weeks to dissolve completely. The copper that becomes plated onto the steel cathodes is 99.99% pure, and is called *cathode copper*. The cathode copper is stripped off of the steel plates and used in manufacturing a vast array of goods, from electronics to coins to cooking pots.



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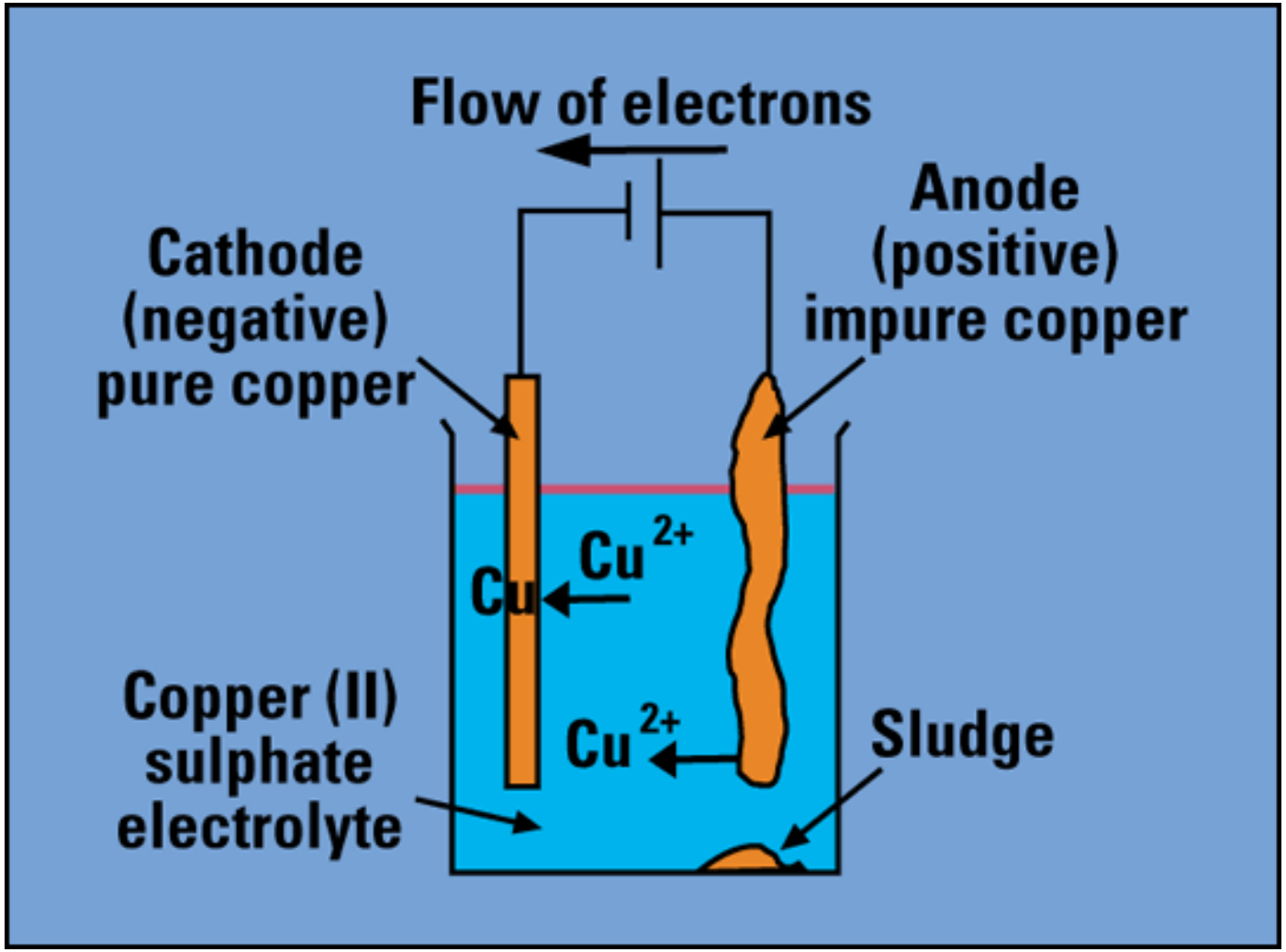
Waste Sludge

The gold and silver-bearing *waste sludge* at the bottom of electrochemical cell is collected and sent to an adjacent electrowinning process to recover the valuable metals.



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Sulphur Dioxide (SO_2)

The hot *sulphur dioxide* gas given off in the furnace and the converter is captured and piped to a steam power plant where it's used to heat a boiler that produces steam to drive a turbine and generate electricity. Once cooled, the particulates in the gas are removed and the sulphur dioxide is passed through a structure called a *shed deck* where water is fed over a series of baffles, which enroute dissolve the gas to form – sulphuric acid (H_2SO_4). The sulphuric acid may be used in electrorefining, in making fertilizer, or sold to market for use in many other industrial applications.