Reverberatory furnace smelting

Reverberatory furnaces are long furnaces can treat wet, dry or roasted concentrate. Most of the reverberatory furnaces used in the latter years treated roasted concentrate because putting dry feed materials into the reverberatory furnace is more energy efficient, and because the elimination of some of the sulfur in the roaster results in higher matte grades.

The reverberatory furnace feed is added to the furnace through feed holes along the sides of the furnace. Additional silica is normally added to help form the slag. The furnace is fired with burners using pulverized coal, fuel oil or natural gas and the solid charge is melted.

Reverberatory furnaces can additionally be fed with molten slag from the later converting stage to recover the contained copper and other materials with a high copper content.

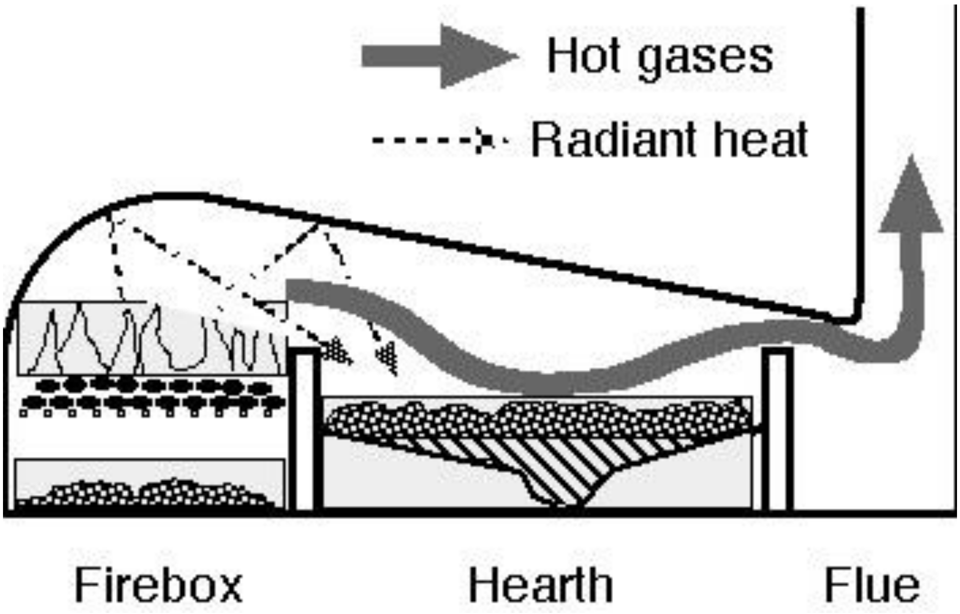
Because the reverberatory furnace bath is quiescent (خاموش), very little oxidation of the feed occurs (and thus very little sulfur is eliminated from the concentrate). It is essentially a melting process. Consequently, wet-charged reverberatory furnaces have less copper in their matte product than calcine-charged furnaces, and they also have lower copper losses to slag. Gill quotes a copper in slag value of 0.23% for a wet-charged reverberatory furnace vs 0.37% for a calcine-charged furnace.

In the case of calcine-charged furnaces, a significant portion of the sulfur has been eliminated during the roasting stage, and the calcine consists of a mixture of copper and iron oxides and sulfides. The reverberatory furnace acts to allow these species to approach chemical equilibrium at the furnace operating temperature (approximately 1600 °C at the burner end of the furnace and about 1200 °C at the flue end; the matte is about 1100 °C and the slag is about 1195 °C). In this equilibration process, oxygen associated with copper compounds exchanges with sulfur associated with iron compounds, increasing the iron oxide content of the furnace, and the iron oxides interact with silica and other oxide materials to form the slag.

The main equilibration reaction is:

$$Cu_2O + FeS = Cu_2S + FeO$$

The slag and the matte form distinct layers that can be removed from the furnace as separate streams. The slag layer is periodically allowed to flow through a hole in the wall of the furnace above the height of the matte layer. The matte is removed by



draining it through a hole into ladles for it to be carried by crane to the converters. This draining process is known as *tapping* the furnace. The matte taphole is normally a hole through a water-cooled copper block that prevents erosion of the refractory bricks lining the furnace. When the removal of the matte or slag is complete, the hole is normally plugged with clay, which is removed when the furnace is ready to be tapped again.

Reverberatory furnaces were often used to treat molten converter slag to recover contained copper. This would be poured into the furnaces from ladles carried by cranes. However, the converter slag is high in magnetite and some of this magnetite would precipitate from the converter slag (due to its higher melting point), forming an accretion on the hearth of the reverberatory furnace and necessitating shut downs of the furnace to remove the accretion. This accretion formation limits the quantity of converter slag that can be treated in a reverberatory furnace.

While reverberatory furnaces have very low copper losses to slag, they are not very energy-efficient and the low concentrations of sulfur dioxide in their offgases make its capture uneconomic. Consequently, smelter operators devoted a lot of money in the 1970s and 1980s to developing new, more efficient copper smelting processes. In addition, flash smelting technologies had been developed in earlier years and began to replace reverberatory furnaces. By 2002, 20 of the 30 reverberatory furnaces still operating in 1994 had been shut down.