

Lecture 20 Smelting

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Key words: Matte smelting, Flash smelting ,Reduction smelting

Preamble

Smelting is a unit process for pyro metallurgical extraction of metal in which gangue minerals are separated from the metal in liquid state. The components of the materials are heated above the melting points so that they are separated in the liquid state. When metal is separated as molten sulphides, the process is called matte smelting and when metal is separated as liquid metal it is called reduction smelting. This lecture concerns with the matte smelting and few other lectures will be devoted on materials and heat balance in matte smelting. Brief description of matte smelting is given so that readers can apply to solve materials and heat balance problems. For details consult any book on non-ferrous metals extraction.

Matte smelting

Matte is a molten mixture of sulphides. Of the greatest industrial importance is iron- copper matte which is an intermediate product in the extraction of copper from sulphide ores. In production of nickel, matte of copper-nickel is an intermediate product. Next is copper- nickel matte.

One advantage of matte smelting is its low melting point which makes it possible to smelt sulphide ores at lower temperatures than required for metals. Thus a matte with equal amounts of copper and iron sulphide melts below 1000°C, whereas an alloy of Fe and Cu would melt at around 1400°C. This leads to lower thermal energy requirements and gangue minerals can be separated easily as slag. Thus matte smelting comprises of the following inputs and output

Roast copper ore + flux + air fuel (if need) + heat = Matte + slag + gas.

What is Matte

Matte as described earlier is usually a molten mixture of iron and copper sulphides. Minor amounts of other sulphides may be present, Copper grade of matte is important. Whenever matte grade is given in the problem, it means copper grade and is defined as

$$\text{Cu grade} = \frac{\text{Amount of Cu in matte}}{\text{Amount of Cu}_2\text{S} + \text{FeS}} \times 100$$

Assuming that matte consists of Cu_2S and FeS in copper smelting. Density of matte is 5 to 5.5/cm³ and melting point depends on proportion of $\text{Cu}_2\text{S} + \text{FeS}$ and may range in between 1100 – 1200°C.

What is a Slag

Slag is a molten mixture of mainly oxides and unreduced sulphides. Limestone or lime is added as a flux. Slag usually consists of SiO_2 , Al_2O_3 , CaO , CuO , FeO , Fe_2O_3 and Fe_3O_4 . Density of slag is 2.8 – 3.8g/cm³.

Industrial copper smelting

Roast concentrate is heated in a reverberatory furnace. It is a long hearth furnace, covered with a roof and heated by combustion of oil or powdered coal.

The furnace is charged with hot pre roasted calcine or with wet flotation concentrate. Silica is added to flux FeO and to give a suitable slag. In some plants lime or limestone is also added. The molten matte is tapped from tap holes along the middle of the furnace, whereas slag is tapped from the flue gas end of the furnace.

The temperature is kept about 1200°C. Hot gases carry sufficient amount of heat and are usually passed through a steam boiler before then go to gas cleaning and discharge.

Copper content of slag is about 0.3 – 0.6%

In flash smelting finely ground ore, together with flux is introduced through a suitable burner. The matte and slag sink whereas the furnace gases are removed through the off take. In flash smelting preheated air or pure oxygen is used to produce required amount of heat.

In most cases sufficient heat is generated by oxidation of FeS . Low grade concentrate contains more FeS . Flash smelting combines both roasting and smelting.

Exercise in matte smelting

- 1) a) In a copper ore chalcopryite is 34%, Pyrite 30% and SiO_2 36%. Determine the % of copper, iron and sulphur
b) What would be the % gangue in a chalcocite ore if the copper content is same as in 1a)? The ore contains Cu_2S .

c) What would be the entire % composition of matte containing 38% copper when the matte is expressed by the formula $m\text{Cu}_2\text{S} \cdot n\text{FeS}$?

Solution:

a) % Cu = 11.83%

$$\% \text{ Fe} = 24.35\%$$

$$\% \text{ S} = 27.83\%$$

b) % gangue is 85.21

c) $0.38 = \frac{\text{Amount of Cu}}{\text{Amount of Cu}_2\text{S} + \text{Amount of FeS}}$

$$= \frac{128m}{160m + 88n}$$

$$\frac{m}{n} = 0.5$$

Formula is $\text{Cu}_2\text{S} \cdot 2\text{FeS}$

2) If a copper ore containing 34% chalcopyrite, 30% FeS_2 and 36% SiO_2 is fused down and only excess sulphur is eliminated, what would be the matte grade?

$$\begin{aligned} \text{Matte grade} &= \frac{\% \text{ Cu}}{\% \text{ Cu}_2\text{S} + \% \text{ FeS}} \times 100 \\ &= 22.2\% \end{aligned}$$

References for the lectures 20 to 25

1. Ray, H.S; Sridhar, R and Abraham, K.P: Extraction of non ferrous metals.
2. Rosenquist : Principles of extractive metallurgy
3. Butts, Allison: Metallurgical Problems, McGraw Hill Book Company, 1943