Lecture 21 Matte smelting: Materials balance

Contents:

Problem 1

A copper ore has the following proximate analysis $(\text{wt.}\,\%)$:

Cu_2S 20, FeS_2 56,and SiO_2 24.

It is smelted in a reverberatory furnace using pure limestone as a flux. The slag has 36% $FeO$and 21% CaO.

Calculate (per 1000 of ore) weight of limestone, slag and matte.

Solution:

In solving material balance it is importantto have understood the chemistry of matte smelting.

In this problem slag consists of 36% FeO and 21% CaO slag will have all SiO_2 in slag

$\%\ SiO_2$ in slag $= 43\%$.

All $\mathbf{SiO_2}$ of ore enters into slag. $\mathbf{SiO_2}$balance gives weight of slag $\mathbf{558.1\ kg}$.

To find weight of limestone we have to calculate CaO.

$\text{Amount of limestone} = 209.3\ \text{kg}.$

Matt is a mixture of $Cu_2S + FeS$. for all calculation purposes. There is no loss of Cu in slag. All copper of ore enter into matte.

Thereis loss of iron in slag.

$$\text{Fe in matte} = \text{Total iron} - \text{iron in slag}$$

Calculation gives weight of matte $\mathbf{365\ kg}$.

Problem2

A copper smelter smelts the ore of the following composition given below in weight percent: $Cu\ 10\%, Fe\ 30\%, S\ 10\%, SiO_2 33\%, CaO 7\%,\ \ Al_2O_3\ 4\%, H_2O\ 6\%$. Limestone of composition $94\%\ CaCO_3$ and $6\% SiO_2$ is one-fifth of the weight of the ore. The coke is 12% of the ore and its ultimate analysis is $(wt.\%) C\ 82, SiO_2 8, Al_2O_3\ 5, Fe\ 2, S\ 2, H_2O\ 1$. During smelting 25% of the total sulphur charged is oxidized as SO_2. The analysis of dry flue gas (In Volume %) $SO_2\ 0.9, CO_2 11.4, O_2\ 9.2, N_2 78.5$.No copper is lost in slag and ignore the flue dust.

Determine (for 1000kg ore):

a) The weight of matte and its grade,
b) Weight and composition of slag,
c) Volume of gases (dry), calculated from sulphur and carbon content,
d) Cubic meter of air.

Solution: Basis is 1000kg ore.

Matte consists of $Cu_2S + FeS$.

Performing S balance and Cu balance one can find S combined with Cu_2S and then amount of FeS

Weight of matt $\mathbf{267.4kg}$ and its Grade is $\mathbf{37.4}\%$

Slag consists of SiO_2, Al_2O_3, CaO and FeO, since all Fedoes not enter into matte.

One can find weight of each component

Weight of slag is 845.2 kg.

SiO_2	41.6%
Al_2O_3	5.5%
CaO	20.7%
FeO	32.2%

Volume of gases

On performing S and C balance

$$\mathbf{Amount\ of\ flue\ gas\ = 88.4\ kg\ mols.}$$

$$\mathbf{N_2 balance\ gives\ air = 1972m^3},$$

Problem 3

The proximate analysis of copper concentrate $(wt.\%)$ is as follows:

Cu_2 S 20%, $FeS_2 49\%$, $SiO_2 26\%$, $Al_2O_3 5\%$. The concentrate is smelted in a furnace in presence of iron ore and limestone. The analysis of iron ore is 81% Fe_2O_3 and 19% SiO_2 and that of limestone is 93% $CaCO_3$and 7% SiO_2. The grade of matte is 45% and the ratio of SiO_2: FeO: CaO in slag is $45: 40: 15$. The oil amounts to $12\%$of the charge and analyzes 85% carbon and 15% hydrogen. The air used is 10% excess than theoretical required for smelting

Calculate (per tonne of concentrate):

a) Weight of each flux and weight of slag.
b) Volume of air and % composition of gases.

As said in lecture 20, fluxes are used in matte smelting to facilitate slag formation and removal of SiO_2.

Let x kg iron ore y kg limestone and z kg slag.

One can perform SiO_2, CaO and iron balance

1) SiO_2 in concentrate + SiO_2 in iron ore + SiO_2 in limestone = SiO_2in slag
2) CaO in $CaCO_3$ = CaO in slag
3) Fe in concentrate + iron in iron ore = Fe in matte + Fe in slag

We can form 3 equations with 3 unknown.

$$x = 133.6 \text{ kg iron ore}$$

$$y = 191.5 \text{ kg limestone}$$

$$x = 664.0 \text{ kg slag}$$

Volume of air:

Air used for combustion and oxidation of sulphur to SO_2 and Fe to FeO.

$$\text{Amount of oil} = 159 \text{ kg}$$

Assuming complete combustion, combustion reaction

$$C + O_2 = CO_2$$

$$H_2 + \frac{1}{2}O_2 = H_2$$

Oxidation reactions are

$$Fe + 0.5\ O_2 = FeO$$

$$S + O_2 = SO_2$$

Theoretical O_2 required from air $= O_2$ for combustion $+ O_2$ for oxidation $- O_2$ available from Fe_2O_3 or iron ore.

Actual air $= 10\%$ of theoretical air.

It is advisable that the reader should calculate using the above balances.

$$\text{Acutal amount of air} = 2878\ m^3$$

Composition of gases

	%
CO_2	5.86
SO_2	5.01
H_2O	4.70
N_2	79.50
O_2	1.93

$$\text{Volume of gases} = 2858\ m^3$$

Conclusion:
in this lecture technique to solve material balance problems in matte smelting is illustrated. There could be other procedure also which may be simpler that what presented here. The lecturer of this course would be extremely happy if the reader innovate any new procedure to solve the problems.