

## Lecture 21 Matte smelting: Materials balance

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### Problem 1

A copper ore has the following proximate analysis (wt. %):

$\text{Cu}_2\text{S}$  20,  $\text{FeS}_2$  56, and  $\text{SiO}_2$  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 important to have understood the chemistry of matte smelting.

In this problem slag consists of 36% FeO and 21% CaO slag will have all  $\text{SiO}_2$  in slag

%  $\text{SiO}_2$  in slag = 43%.

**All  $\text{SiO}_2$  of ore enters into slag.  $\text{SiO}_2$  balance gives weight of slag 558.1 kg.**

To find weight of limestone we have to calculate CaO.

Amount of limestone = 209.3 kg.

Matte is a mixture of  $\text{Cu}_2\text{S}$  + FeS. for all calculation purposes. There is no loss of Cu in slag. All copper of ore enter into matte.

There is loss of iron in slag.

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

**Calculation gives weight of matte 365 kg.**

### Problem 2

A copper smelter smelts the ore of the following composition given below in weight percent: Cu 10%, Fe 30%, S 10%, SiO<sub>2</sub> 33%, CaO 7%, Al<sub>2</sub>O<sub>3</sub> 4%, H<sub>2</sub>O 6%. Limestone of composition 94% CaCO<sub>3</sub> and 6% SiO<sub>2</sub> 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<sub>2</sub> 8, Al<sub>2</sub>O<sub>3</sub> 5, Fe 2, S 2, H<sub>2</sub>O 1. During smelting 25% of the total sulphur charged is oxidized as SO<sub>2</sub>. The analysis of dry flue gas (In Volume %) SO<sub>2</sub> 0.9, CO<sub>2</sub> 11.4, O<sub>2</sub> 9.2, N<sub>2</sub> 78.5. No copper is lost in slag and ignore the flue dust.

Determine (for 1000kg ore):

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

**Solution:** Basis is 1000kg ore.

Matte consists of Cu<sub>2</sub>S + FeS.

Performing S balance and Cu balance one can find S combined with Cu<sub>2</sub>S and then amount of FeS

**Weight of matt 267. 4kg and its Grade is 37. 4%**

Slag consists of SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, CaO and FeO, since all Fe does not enter into matte.

One can find weight of each component

Weight of slag is 845.2 kg.

SiO <sub>2</sub>	41.6%
Al <sub>2</sub> O <sub>3</sub>	5.5%
CaO	20.7%
FeO	32.2%

### Volume of gases

On performing S and C balance

**Amount of flue gas = 88. 4 kg mols.**

**N<sub>2</sub> balance gives air = 1972m<sup>3</sup>,**

### Problem 3

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

Cu<sub>2</sub>S 20%, FeS<sub>2</sub> 49%, SiO<sub>2</sub> 26%, Al<sub>2</sub>O<sub>3</sub> 5%. The concentrate is smelted in a furnace in presence of iron ore and limestone. The analysis of iron ore is 81% Fe<sub>2</sub>O<sub>3</sub> and 19% SiO<sub>2</sub> and that of limestone is 93% CaCO<sub>3</sub> and 7% SiO<sub>2</sub>. The grade of matte is 45% and the ratio of SiO<sub>2</sub>: 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<sub>2</sub>.

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

One can perform SiO<sub>2</sub>, CaO and iron balance

- 1) SiO<sub>2</sub> in concentrate + SiO<sub>2</sub> in iron ore + SiO<sub>2</sub> in limestone = SiO<sub>2</sub> in slag
- 2) CaO in CaCO<sub>3</sub> = 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.

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

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

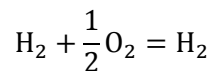
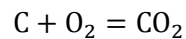
$$z = 664.0 \text{ kg slag}$$

#### Volume of air:

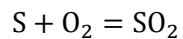
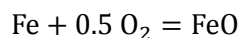
Air used for combustion and oxidation of sulphur to SO<sub>2</sub> and Fe to FeO.

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

Assuming complete combustion, combustion reaction



Oxidation reactions are



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.

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

Composition of gases

	%
$CO_2$	5.86
$SO_2$	5.01
$H_2O$	4.70
$N_2$	79.50
$O_2$	1.93

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

**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 than what presented here. The lecturer of this course would be extremely happy if the reader innovates any new procedure to solve the problems.