Lecture 16 Material balance in roasting:

Contents

Basics of materials balance

Calculation procedure

Problem (Do your Self)

Keywords: Roasting, Material balance, Heat balance, Dead Roasting

Basics of materials balance:

The elements of material balance are illustrated through a problem. Consider roasting of copper ore concentrate: $\mathrm{Cu}\ 8.8\%, \mathrm{SiO_2} 19\%, \mathrm{Fe} 29.7\%, \mathrm{S}\ 36.9\%, \mathrm{Al_2O_3} 5.3\%$ and $\mathrm{CaO}\ 0.3\%$. it is roasted and the roasted ore has the following composition $(\mathrm{wt}\%)\mathrm{Cu} = 11.1, \mathrm{SiO_2} 24.0,\ \mathrm{Fe} = 37.6,\ \mathrm{S} = 10, \mathrm{Al_2O_3} = 6.7, \mathrm{CaO} = 0.4$ and $\mathrm{O_2} = 10.2$

All copper in the roasted ore is as $\mathrm{Cu_2S}$ and Fe partly oxidized to $\mathrm{Fe_2O_3}$ and partly to $\mathrm{Fe_3O_4}$. During roasting $5000\ \mathrm{Cu\ m/ton}$ of ore concentrate is used. Fuel is used ant its amount is $5\mathrm{g\ C/ton}$ of ore. Of the sulphur oxidized, 85% goes to $\mathrm{SO_2}$ and 15% goes to $\mathrm{SO_3}$. Find

a) Weight of roasted ore/ ton of concentrate and analysis of roasted ore.
b) % sulphur eliminated
c) Volume and composition of gases
d) Excess air used for combustion and roasting

Calculation procedure:

1. $\mathrm{SiO_2}, \mathrm{Al_2O_3}$ and CaO of ore concentrate enter into roast product.
2. Fe is oxidized to $\mathrm{Fe_2O_3}$ and $\mathrm{Fe_2O_4}$ depending on oxidizing condition.
3. In partial roasting, usually not all S of concentrate is oxidized.
4. Sulphur in the roast product is present as $\mathrm{Cu_2S}$ and Fe S.
5. In the roast product oxygen is in combined form either with Fe or with Cu.
6. Theoretical amount of air can always be calculated once the reactants and products are specified. Here balanced chemical equation helps very often to calculate theoretical air.
7. 1 mole of air contains 0.21mols of $\mathrm{O_2}$ and 0.79mols of $\mathrm{N_2}$.1 mol of oxygen and 3.76mols of $\mathrm{N_2}$ forms 4.76mols

To find weight of roasted ore one can do either $\mathrm{SiO_2}$ balance or $\mathrm{Al_2O_3}$ balance or even CaO balance.

$\mathrm{SiO_2}$ balance and $\mathrm{Al_2O_3}$ balance give weight of roasted product $791\mathrm{kg}$.

Roasted ore contains $\mathrm{Cu_2S}, \mathrm{FeS}, \mathrm{Fe_2O_3}, \mathrm{Fe_3O_3}, \mathrm{CaO}\ \mathrm{SiO_2}$ and $\mathrm{Al_2O_3}$.

Amount of CaO, SiO_2 and Al_2O_3 can be determined from their percentages in roast product, it is 3.2Kg, 190Kg and 53 Kg respectively.

All Cu in roasted ore is present as Cu_2S, therefore amount of $Cu_2S = 109.75$ Kg.

It is not known in what form Fe is present in the roasted product. Problem says Fe is present as $Fe_2O_3$and Fe_3O_4. It is important to perform S balance.

Sulphur in roasted ore $= 79.1$ Kg.

S in Cu_2S + S in FeS $= 79.1$.

From the amount of Cu_2S we can find S in Cu_2S and we can obtain S in FeS which is equal to 57.15Kg

Amount of $FeS = 157.16$ kg

Let x Kg Fe_2O_3 and y Kg Fe_3O_4 in roasted ore.

Feoxidized to Fe_2O_3 and Fe_3O_4 = Total Fe − Fe in FeS $= 197$ Kg.

O_2in roasted ore is either with Fe_2O_3 or Fe_3O_4.

Performing Fe balance and oxygen balance

$$0.7\,x + 0.72\,y = 197$$

$$0.3\,x + 0.28\,y = 81$$

$x = 158$ kg and $y = 120$ kg.

Proximate analysis of roast product is

Cu_2S	109.75
Al_2O_3	53.00
SiO_2	190.00
CaO	3.20
FeS	157.16
Fe_2O_3	158.00
Fe_3O_4	120.00
Total	791.11

Volume and percentage composition of gases

$$\textbf{Total S oxidized} = 9.059\ \textbf{kg mols}$$

$$\textbf{S oxidized to } SO_2 = 7.70\ \textbf{kg mols}$$

$$\mathbf{S\ oxidized\ to\ SO_3 = 1.36\ kg\ mols}$$

Since following oxidation reactions are occurring:

$$S + O_2 = SO_2$$

$$S + 1.5\ O_2 = SO_3$$

$$2\ Fe + 1.5\ O_2 = Fe_2O_3$$

$$3Fe + 2\ O_2 = Fe_3O_4$$

$$C + O_2 = CO_2$$

Form the amounts of elements oxidized

$$\text{Stoichiometric oxygen} = 12.667\ \text{kg mols}$$

$$\text{Actual}O_2\ \text{supplied} = \frac{5000 \times 0.21}{22.4} = 46.875\ \text{kg mols}$$

$$\text{Actual}N_2\ \text{supplied} = 176.34\ \text{kg mols}$$

$$\text{excess}\ O_2 = 34.21\ \text{kg mols}$$

Composition	Kg mols	%
SO_2	7.70	3.50
SO_3	1.36	0.63
O_2	34.21	15.54
N_2	176.34	80.14
CO_2	0.42	0.19

$$\mathbf{Volume\ of\ gases = 4928.67\ m^3}$$

$$\mathbf{excess\ air} = \frac{\mathbf{excess\ O_2}}{\mathbf{Theoretical\ O_2}} \times \mathbf{100}$$

$$= \mathbf{273.7}\%$$

Problem (Do your self)

Ore concentrate of the composition $6\%\text{Cu}, 35\%$ S and gangue is roasted with oxygen (derived from air). O_2is200% excess. In the concentrate all Cu is in form of Cu Fe S_2 and sulphur also forms pyrite. Calculate per 1000 Kg concentrate

i) Amount of Cu Fe S_2, Fe S_2 and gangue in concentrate
ii) Theoretical amount of oxygen
iii) Actual amount of air
iv) Volume of SO_2 and amount of Fe_2O_3.

Answer

i) Cu FeS_2 172.5 kg, $\text{FeS}_2 = 543.75$ kg and gangue $= 283.75$ kg
ii) $347.4\ \text{m}^3$
iii) $4962\ \text{m}^3$
iv) $24\ \text{J m}^3$ and 438 kg