

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: Cu 8.8%, SiO₂ 19%, Fe 29.7%, S 36.9%, Al₂O₃ 5.3% and CaO 0.3%. It is roasted and the roasted ore has the following composition (wt%) Cu = 11.1, SiO₂ 24.0, Fe = 37.6, S = 10, Al₂O₃ = 6.7, CaO = 0.4 and O₂ = 10.2

All copper in the roasted ore is as Cu₂S and Fe partly oxidized to Fe₂O₃ and partly to Fe₃O₄. During roasting 5000 Cu m/ton of ore concentrate is used. Fuel is used and its amount is 5g C/ton of ore. Of the sulphur oxidized, 85% goes to SO₂ and 15% goes to SO₃. Find

- Weight of roasted ore/ ton of concentrate and analysis of roasted ore.
- % sulphur eliminated
- Volume and composition of gases
- Excess air used for combustion and roasting

Calculation procedure:

- SiO₂, Al₂O₃ and CaO of ore concentrate enter into roast product.
- Fe is oxidized to Fe₂O₃ and Fe₃O₄ depending on oxidizing condition.
- In partial roasting, usually not all S of concentrate is oxidized.
- Sulphur in the roast product is present as Cu₂S and FeS.
- In the roast product oxygen is in combined form either with Fe or with Cu.
- 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.
- 1 mole of air contains 0.21 mols of O₂ and 0.79 mols of N₂. 1 mol of oxygen and 3.76 mols of N₂ forms 4.76 mols

To find weight of roasted ore one can do either SiO₂ balance or Al₂O₃ balance or even CaO balance.

SiO₂ balance and Al₂O₃ balance give weight of roasted product 791kg.

Roasted ore contains Cu₂S, FeS, Fe₂O₃, Fe₃O₄, CaO, SiO₂ and Al₂O₃.

Amount of CaO, SiO₂ and Al₂O₃ 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 Cu₂S, therefore amount of Cu₂S = 109.75 Kg.

It is not known in what form Fe is present in the roasted product. Problem says Fe is present as Fe₂O₃ and Fe₃O₄. It is important to perform S balance.

Sulphur in roasted ore = 79.1 Kg.

S in Cu₂S + S in FeS = 79.1.

From the amount of Cu₂S we can find S in Cu₂S and we can obtain S in FeS which is equal to 57.15Kg

Amount of FeS = 157.16 kg

Let x Kg Fe₂O₃ and y Kg Fe₃O₄ in roasted ore.

Fe oxidized to Fe₂O₃ and Fe₃O₄ = Total Fe – Fe in FeS = 197 Kg.

O₂ in roasted ore is either with Fe₂O₃ or Fe₃O₄.

Performing Fe balance and oxygen balance

$$0.7x + 0.72y = 197$$

$$0.3x + 0.28y = 81$$

x = 158 kg and y = 120 kg.

Proximate analysis of roast product is

Cu ₂ S	109.75
Al ₂ O ₃	53.00
SiO ₂	190.00
CaO	3.20
FeS	157.16
Fe ₂ O ₃	158.00
Fe ₃ O ₄	120.00
Total	791.11

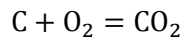
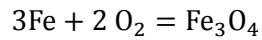
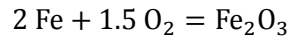
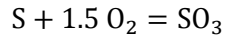
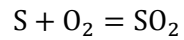
Volume and percentage composition of gases

Total S oxidized = 9.059 kg mols

S oxidized to SO₂ = 7.70 kg mols

S oxidized to SO₃ = 1.36 kg mols

Since following oxidation reactions are occurring:



Form the amounts of elements oxidized

Stoichiometric oxygen = 12.667 kg mols

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

Actual N₂ supplied = 176.34 kg mols

excess O₂ = 34.21 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

Volume of gases = 4928.67 m³

$$\begin{aligned} \text{excess air} &= \frac{\text{excess } O_2}{\text{Theoretical } O_2} \times 100 \\ &= 273.7\% \end{aligned}$$

Problem (Do your self)

Ore concentrate of the composition 6%Cu, 35% S and gangue is roasted with oxygen (derived from air). O_2 is 200% 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, FeS_2 = 543.75 kg and gangue = 283.75 kg
- ii) $347.4 m^3$
- iii) $4962 m^3$
- iv) $24 J m^3$ and 438 kg