Lecture 22: Heat balance in matte smelting 1

Contents:

Problem 1

Problem2

Problem 1

Copper ore contains 16% copper, 30% iron, 32% sulphur and 22% SiO_2 .The smelting of this ore produces a matte whose grade is 50%. The flux is limestone and the slag contains 14%CaO.

Heat of formation of slag $140\ \mathrm{cal/g}$ of slag .Air is supplied at 298k .Gasesleave the furnace at 500k. Slag and matte leave the furnace at 1400K.

Calculate:

- **a)** Weight of $CaCO_3$ per tonne of ore.
- **b)** Total heat supplied from all sources per tonne of ore.
- **c)** Total heat leaving the furnace(itemized)

Solution:

Problem on material balance have been illustrated in lectures 20 and 21. Reader should do materials balance. Materialbalance result is

Matte kg	**Slag Kg**	**Gases kg mole**
Cu_2S = 200 FeS = 120	Fe O 287.5	$SO_2$7.39
	$SiO_2$220.0	CO_2 1.475
	CaO 82.6	N_2 35.29

Weight of $CaCO_3$147.5Kg

Heat content Data in Kcal/kgmol

$$\mathrm{H}_{500} - H_{298}|\mathrm{So}_2 = 2108$$

$\mathrm{H}_{500} - H_{298}|\mathrm{N}_2 = 1418$

$\mathrm{H}_{500} - H_{298}|\mathrm{Co}_2 = 1987$

$\mathrm{H}_{1400} - H_{298}|\mathrm{Sio}_2 = 17370$

$\mathrm{H}_{1400} - \mathrm{H}_{298}|\mathrm{Ca}_\mathrm{O} = 13430$

$H_{1400} - H_{298}|Fe_O = 14520$

$$\text{Heat content of matte at its melting point (1273 x)} = 205 \ \frac{\text{kcal}}{\text{kgmol}}$$

Specific heat of liquid matte $= 0.14 \ \frac{\text{kcal}}{\text{kg°C}}$

Heat of formation of slag $= 140 \frac{\text{kcal}}{\text{kg}}$

Standard heat of formation of compounds at 298K $\left(\frac{\text{kcal}}{\text{kgmol}}\right)$

FeO $= -64300$

FeS $= -23100$

$SO_2 = -70940$

CaO $= -151600$

$CO_2 = -94450$

$CaCO_3 = -289500$

Heat Balance:

The readers should calculate themselves the various heat inputs and outputs from the date given above. The calculated values are:

Sensible heat in reactants =0

Heat of reaction $= -781000$ kcal (exothermic)

Heat of decomposition $= +64088$ kcal (endothermic)

Heat out by slag $= 224092$ kcal

Heat out by matte $= 71290$ kcal

Heat out by gases $= 68550$ kcal

Heat loss $= 1070$ of heat input

Heat input	**kcal**	**Heat output**	**kcal**
Heat of reaction	781000	Matte	71290

Heat absorbed	-64088	slag	220492
	716912	gases	68550
		Losses	71691
			432023

Excess heat =284889 kcal

Problem 2

A dry flotation concentrates of composition (%)$\mathrm{Cu} = 26, \mathrm{Fe} = 22,\ \mathrm{S} = 27\ , \mathrm{SiO_2} =\ 15\ , \mathrm{CaO} = 6.5$ and $\mathrm{Al_2O_3}\ =\ 1$ is smelted in a reverberatory furnace using air. 65% of total sulphur is oxidized to $\mathrm{SO_2}$, and other products are matte and slag.All Cuis present as $\mathrm{CuFeS_2}$.Perform materials and heat balance. For the calculations the gas, matte and slag leave the furnace at 1500K.

Material balance for 100 g concentrated

Matte (g)	Slag (g)	Gases (g mole)
Cu_2S 32.5	FeO 21.3	SO_2 0.548
FeS 8.1	Sio_2 15.0	N_2 2.616
	Al_2O_3 1.0	
	CaO 6.5	

Some Thermo chemical data are given in lecture 21.

Heat of decomposition of $\mathrm{CuFeS_2}\ = 38975\ \mathrm{Cal\ mole^{-1}}$

Calmole^{-1}

$\mathrm{H_{1500}} - \mathrm{H_{298}}|\mathrm{Cu_{2S}}\ = 28790$

$\mathrm{H_{1500}} - \mathrm{H_{298}}|\mathrm{Fe_S}\ = 25620$

$\mathrm{H_{1500}} - \mathrm{H_{298}}|\mathrm{Ca_O}\ = 33840$

$\mathrm{H_{1500}} - \mathrm{H_{298}}|\mathrm{Fe_O}\ = 23310$

$\mathrm{H_{1500}} - \mathrm{H_{298}}|\mathrm{SiO_2} = 19930$

$\mathrm{H_{1500}} - \mathrm{H_{298}}|\mathrm{Al_2O_3} = 59060$

$\mathrm{H_{1500}} - \mathrm{H_{298}}|\mathrm{SO_2} = 14840$

$\mathrm{H_{1500}} - \mathrm{H_{298}}|\mathrm{N_2} = 9110$

Heat input and output can be calculated from the data given above.

Below is the result.

Heat input	Cal	Heat output	Cal
Heat of reaction	58196	Heat Absorbed by decomposition of $CuFeS_2$	8526
		Matte	8201
		Slag	16616
		Gases	31964
		Subtotal	65307
		Heat loss as10% of output	6530
		Total heat output	77831

Heat deficit is 13640 cal|100g Concentrate.

b)Calculation to provide heat deficit

i) Preheating of air

Preheating of air aids sensible heat. Air preheat temperature is important, this temperature can be calculated by equating heat loss equal to heat input by airif mean heat capacity of air is $7.5 \frac{\text{cal}}{\text{mole°C}}$

Temperature of preheat air $= 574°C$

ii) By burning natural gas

Each mole of methane produces 191750 cal of heat on combustion. Out of which some amount of heat will be carried away by the products of combustion of methane at the furnace temperature and is assumed to be 1500K. The products of combustion are CO_2, H_2O and N_2,when methane is burnt with strichiometric amount of air.

$$\text{Heat available on combustion of methane} = 85963 \text{ cal/mole}$$

$$CH_4 \text{ required} \quad = 0.16\text{mole} = 35.8\text{m}^3\text{| ton concentrate}$$

We have to recalculate composition of exit gas. Therevisedcomposition of the gas is

%

SO_2 11.31

CO_2 3.30

H_2O 6.60

N_2 78.79

iii) By enriching air with oxygen. Oxygen enrichment of air decreases nitrogen and hence heat carried away by the flue gas will also decrease. What amount of oxygen must beadded to meet the heat deficit?

Answer 85m3|ton concentrate

Revised composition of flue gas$SO_2 = 31.5\%$

$$N_2 \quad = 68.5\%$$