Material and heat balance in converting

By solving we get.

Total flux = 10941 kg and total slag = 23505 kg.

Copper balance gives weight of blister $^{\text{copper} = 20748\text{kg}}$

Slag forming stage is in two stages. One has to calculate moles of oxygen for first stage and second stage. The reactions are

$FeS + 1.5\ O_2 = FeO + SO_2$

$Cu_2S + 2\ O_2 = CuO + SO_2$

Moles of oxygen for 1st stage = 226.32

Moles of oxygen for 2nd stage = 84.95

Moles of oxygen for copper formation = 162

total O_2 moles = 473.29kg moles

Air for entire blow = 50484 m^3

Time for 1st slagging = 219 minutes

Time for 2nd slagging = 82 minutes

Time for blister copper = 157 minutes

Do yourself-1

A copper converter treats per charge 10 tons of $^{40\%}$ matte. Blast is furnished at the rate at of $^{100\text{Cu.m}}$. per minute. Before adding flux a preliminary blow of 9 min is given to produce a magnetite coating, which analyzes as $^{Fe_3O_4\ 75\%, FeO\ 5\%, CuO\ 5\%,}$ and unoxidized constituents $^{15\%}$. Assume that this is entirely corroded by the ^{SiO_2}. The flux carries Cu_2S 3%; FeS 27%; SiO_2 52%.

The blister copper is $^{100\%\ Cu}$. The converter gases carry no free oxygen.

Required:

a) The weight of magnetite coating produced, flux required and slag made.

b) The weight of blister copper, and the % of copper recovery

c) The blowing time of each stage.

d) The volume and % composition of the converter gases.

Answer

a) Weight of coating: 1184 kg. weight of flux and slag 1998.8kg and 6496kg

b) 3788kg, $^{94\%}$ recovery

c) Slag formation stage; 87.35 minutes and blister ^{Cu} 32 minute.

d) Coating stage; $^{SO_2\ 28.5\%\ N_2\ 71.5\%}$

Slag formation stage; $^{SO_2\ 14.5\%,\ N_2 85.5\%}$

Blister $^{Cu\ SO_2\ 21\%\ N_2\ 79\%}$

Illustration –Heat balance

A copper converter is charged with 40 tons of matte whole copper grade is $^{50\%}$. The flux is $^{9\%\ Cu,\ 18\%\ Fe,\ 10\%\ S\ and\ 56\%\ SiO_2}$. The slag analyses $^{26\%\ SiO_2,\ 65\%\ FeO\ and\ 4\%\ CuO.Fe}$ in flux not as ^{CuFeS_2}, the blister copper contains $^{98\%\ Cu.}$

The matte is charged at 1323K, the flux at 298K, and the blast is at 400K. The bath temperature is 1400K. The slag and gases discharge at 1400K.

Specific heat of matte $^{0.14\ Kcal/Kg\ °C}$ independent of composition; melting point of matte 1273K; Heat content of liquid matte at melting point $^{205\ kcal\ per\ kg}$

Melting point of slag 1393K and specific heat $^{0.25\ kcal/kg\ °C}$; Heat content of liquid slag at melting point $^{300\ kcal\ per\ kg}$. Heat of formation of the slag is 376 kcal per kg of ^{SiO_2}.

In the blister copper formation, bath temperature is 1500K, Heat content of ^{Cu_2S} is at 1500K.gases discharge $^{28790KCal/kg.mole}$at 1500K.Gases discharge at 1400K.

Required: A heat balance of the converter at the end of the slagging period and at the end of the blow

Solution

First we have to perform materials balance:

Some problems on materials balance have already been illustrated. Results of material balance are:

Input (slag making stage)	Output
Matte: 40,000kg	**Slag 22600kg**
Flux: 10500 kg	**Gases SO_2=209.65 kg moles N_2=1193kg moles**
Air : N_2 1193 kg moles O_2 317 kg moles	

Thermo- chemical data:

Heat of formation of slag $= 376$ kcal/kg SiO_2

Heat content of slag at melting point $= 300$ kcal/kg.

Heat of reaction

$FeS + 1.5\ O_2 = FeO + SO_2;\ \Delta H_R^\circ = -112140$ kcal

$Cu_2S + 2\ O_2 = 2CuO + SO_2; \Delta H_R^\circ = -128990$ kcal.

Sensible heat at the respective temperatures in kcal/kg mole is

$H_{400} - H_{298}$ for $N_2 = 710$.

$H_{400} - H_{298}$ for $O_2 = 723$

$H_{1400} - H_{298}$ for $N_2 = 8288$

$H_{1400} - H_{298}$ for $SO_2 = 13432$

Heat input

Sensible heat in air $= 1.08 \times 10^6$ kcal.

Heat input

Sensible heat in flux $= 0$

Heat of reaction of reaction $= 23.65 \times 10^6$ kcal.

Heat output:

Sensible heat in matte $= 8.9 \times 10^6$ kcal

Sensible heat in slag $= 9 \times 10^6$ kcal.

Sensible heat in gases $= 12.7 \times 10^6$ kcal.

Heat balance in blister copper stage.

Materials balance

Input: $Cu_2S = 158$ kg moles

$O_2 + N_2 = 158 + 594$ kg moles

Output: Cu 316 kg moles

Gases $SO_2 = 158$ kg moles and $N_2 = 594$ kg moles

Data

Heat of reaction of **$Cu_2S + O_2 = 2Cu + SO_2$**

$$\nabla H_R^o = -51990 \frac{Kcal}{Kg} mol$$

Heat input

Sensible heat in $Cu_2S = 4.5 \times 10^6$ kcal

Heat reaction = 8.2×10^6 kcal

Heat out put

Sensible heat = 7×10^6 kcal

Sensible heat in blister Cu = 3.55×10^6 kcal

Regferences:

1) Rosenquist : Principles of extractive metallurgy

2) Butts, Allison: Metallurgical Problems, McGraw Hill Book Company, 1943