Lecture 23: Reduction Smelting

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Key words: Ironmaking, imperial smelting process, smelting, metal extraction

Preamble

Reduction and smelting are two independent unit processes employed in mental extraction through pyromettallurgical route. Reduction is carried mostly by carbon. For example reduction of Fe_2O_3, ZnO and PbO. Whereas smelting consists in heating the products to a temperature above the melting point to separate liquid metal from liquid slag. Both unit processes can be carried out simultaneously in one reactor or in two independent interconnected reactors.

Typically lead, zinc and hot metal are produced in a single reactor called blast furnace. In Korex process two independent interconnected reactors are used to produce hot metal. Shaft furnace is connected with a smelter–gasifies unit.

Salient features of lead reduction smelting

In the following lecture we will deal with production of lead. A salient feature of lead blast furnace will be given and the lecture is followed by material balance. A detailed description can be found in the references given at the end of this lecture.

- ➢ Pb is produced by carbon reduction of the sinter containing lead oxide in a lead blast furnace. Sinter consists of $PbS, PbO, PbSO_4, SiO_2, Al_2O_3$ etc
- ➢ Height of blast furnace 8m, top dia 3m, crucible depth. ¾ ^{m} and stack height 5 m.
- ➢ Temperature at bosh $N1200°c$.
- ➢ Air is blown in through 15 tuyeres(15-20) around the bosh to oxidize C charged with sinter which produces required heat.
- ➢ At top of furnace bag houses are provided to collect lead furnaces from outgoing gases.
- ➢ Limestone and quartz are added to make a slag.

Scrap iron is charged .The following reactions occur.

$$PbSiO_3 + Fe = FeSiO_3 + Pb.$$

$$PbO + Fe = FeO + Pb.$$
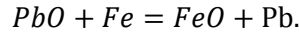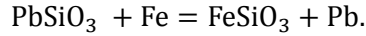
The products of smelting are liquid lead, matte, speiss, slag and gases. Lead has density 11 g/cm^3, matte containing copper has density 5 g/cm^3, whereas speiss has density 6 g/cm^3

Material balance in lead smelting

A) Lead ore concentrate of composition 60%PbS, 4% FeS$_2$, 3% Al$_2$O$_3$, 2% C$_a$O and 31% SiO$_2$ is roasted by using 300% theoretical air. During roasted all FeS$_2$, and 90%PbS is oxidized .Determine for 1000kg concentrate.

     1) Volume of air at 1 atm and 273 K
     2) Amount and composition of roasted product
   3) Amount and composition of flue gas

B) The roasted product determined above is smelted in blast furnace using flux as Fe$_2$O$_3$, and C$_a$CO$_3$ to produce slag having a ratio SiO$_2$: FeO: CaOequal to 35:50:15. The amount of coke is 16% of weight of concentrate. The coke contains 85% C and 15% SiO$_2$. Find

4) Amount of each flux

5) Amount of slag

Solution:

Molecular weight $Pb = 239, Fe = 56, Al = 27, Ca = 40, Si = 28$

Roasting reactions are

$PbS + 1.5O_2 = PbO + SO_2$

$FeS_2 + 2.5O_2 = 2FeO + 2SO_2$
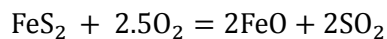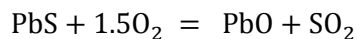
Volume of air = (theoretical amount)x3

Theoretical air can be calculated from the stoichiometric equation.

Volume of air = $135\ m^3$

Roasted product consists of PbS, PbO, FeO, Al$_2$O$_3$, CaO and SiO$_2$. We have done earlier materials balance (Refer lectures 17, 18, 19, 21,).

Amount of roasted product =948 kg

Amount of flue gas=59 kg moles

Smelting of roast product constitutes part B. Flux used is limestone and Fe_2O_3,

$$\text{Amount of } CaCO_3 \text{ (determined from CaO)} = 220 \text{ Kg.}$$

Amount of Fe_2O_3 = 503 Kg

Amount of slag = 984.3 kgy

Do yourself

2) The charge for Pb blast furnace consists of

Roasted Ore   PbO 31% , PbS 19% , SiO_2 40% and feO 10%

 (1000 Kg)

Pyritecinder Fe_2O_3, 88%, CuS_5 5 %, SiO_2 7 %

(600Kg)

CokeC 89 %, SiO_2 11%

(180Kg)

FluxC_aCO_3 100%

(220 Kg)

Matte contains all of Cu, S and 2% Pb. No Pb is lost in slag or gases.

The gases contain $CO: CO_2 = 1: 1$ by volume

Calculate:

   a) Charge balance of furnace
   b) Proximate composition of matte and slag
   c) Volume of blast used (at 1 atm and 273K)

   Answers:

   d) Amount of lead   443 kg
   e) Amount of matte   106.54 Kg
   f) Amount of slag   1106 Kg
   g) Volume of blast = $543m^3$

References for lectures 23 to 30

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