Advanced Master Course
Process Technology of Metals

(Part: Ferrous Process Metallurgy)

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16-08-2011

(2/2011)

Hösaal H 222, Intzestraße 1, IEHK

Time: 9:30-10:30

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Total after approval:
**Task 1: Pelletizing and Sintering**  
6 Points

1.1 Sintering may be defined as “the agglomeration of fine particles into lump”

(a) Which material can be used as a source of heat?  
(0.5 point)

(b) Give one advantage and one disadvantage of sintering process.  
(1.0 point)

1.2 Write down a flow sheet for the iron ore beneficiation.  
(1.5 points)
1.3 What is the meaning of
   a) “Fluxed sinter” (0.5 point)
   b) “Super Fluxed sinter” (0.5 point)

1.4 Pellet production can be divided into 3 distinct stages:
   Stage 1 – Preparation of raw materials
   Stage 2 – Formation of green pellets
   Stage 3 – Firing of green pellets
   (a) Give the grain size of iron ore to be suitable for pelletizing. (0.5 point)
   (b) Give at least one aggregate which can be used for stage 1 (0.5 point)
   (c) What is the function of bentonite in the second stage? (0.5 point)
   (d) What is the main task of the firing step? (0.5 point)
Task 2: Blast Furnace  8 Points

2.1 Give the definitions of the following terms:  

(1.0 point)

a) “Coke windows”

b) “Cohesive zone”

2.2 The Baur-Glaessner-diagram for the reduction of iron oxide by CO/CO\(_2\) gas mixture is shown in the picture below.

(a) Please indicate and label the areas where hematite, magnetite and iron are stable!  

(2.0 points)
(b) Give the temperature and the CO/CO₂-pressure where iron, wustite, hematite and magnetite are coexisting. (1.0 point)

2.3 Is direct reduction possible at temperature lower than 900°C in an efficient way? Why? (1.0 point)

2.4 a) What is the temperature and what is the concentration of sulphur of the hot metal tapping from BF? (1.0 point)
   b) Which processes are used for desulphurisation of hot metal after tapping from blast furnace? (Name at least 2 items) (1.0 point)
   c) What reactions that are happening between hot metal and slag during the desulphurisation? (0.5 point)
   d) Why is sulphur removal from hot metal much easier than that from raw steel? (0.5 point)
Task 3: Oxygen Steelmaking 8 Points

3.1 a) Give the reaction of the most burned five elements of hot metal during the blowing process, and write also down the corresponding phases (with \[\] = soluted in the melt, \{\} = gaseous state, \()\ = soluted in slag). (2.5 points)

b) Write the burning sequence of these five elements. (1.0 points)

3.2 a) What are the tasks of lime in steelmaking? (Give at least 2 items) (1.0 point)

b) Why is lime preferred than limestone in the LD converter process? (Give at least 2 items) (1.0 point)
3.3  a) What is OBM process?  
    b) What are the advantages and disadvantages of OBM compared to the LD-BOF process?

3.4  What is the Laval nozzle? (Give the schematic sketch)

3.5  In which process [N] concentration of liquid raw steel is higher and why?  
    (a) BOF  
    (b) EAF
Task 4: Slags and Fluxes  6 Points

4.1 Give equations representing:
   (a) Formation of di-calcium silicate  
   (b) Slag basicity

4.2 a) Please sketch the ternary system diagram of CaO-Al_2O_3-SiO_2 at 1600 °C 
   with equilibrium (or saturation) lines. 
   b) Draw the line where B1=1 in this ternary system diagram. 
   c) Which point represents the region of particular interest for ladle 
      metallurgy slag?

4.3 FeO-containing slag from EAF or BOF processes must be reduced after tapping 
   in terms of oxygen activity. By which method can that be done? 
   (Give at least 2 items)
4.4 (a) What happens to steel melt and slag if the slag viscosity increases? (0.5 point)

(b) How can you decrease the viscosity of slag? (0.5 point)

4.5 What is a disadvantage of using CaF$_2$ in iron- and steelmaking process? (0.5 point)
Task 5: Electric Steelmaking 6 Points

5.1  
  a) What is the advantage of using graphite as the electrode material in EAF process? (Give at least 2 items) (1.0 point)
  b) How can people diminish the consumption of graphite electrodes in EAF process? (Give at least 2 items) (1.0 point)

5.2  
  a) What are the advantages of foaming slag in electric arc furnace process? (Give at least 2 items) (1.0 point)
  b) Explain the procedure and also write down chemical reactions for generation of foaming slags in electric arc furnace process. (1.0 point)
5.3 DRI can be used as a partial substitute for scrap in electric arc furnace process.
   a) What are advantages of DRI’s used? (0.5 point)
   b) What are disadvantages of DRI’s used? (0.5 point)

5.4 a) What is post combustion? (0.5 point)
   b) When the post combustion is working in the melting process, the beginning of the process or at the end of the process? (0.5 point)
Task 6: Secondary Metallurgy (Ladle Metallurgy) 8 points

6.1 What are the general objectives of “Secondary Metallurgy”?
(Give at least 4 items) (2.0 points)

6.2 a) What is Vacher-Hamilton equilibrium? (Give the value at 1600°C) (0.5 point)

b) What is Sieverts’s law? (0.5 point)

6.3 Draw a RH-plant schematically and label the specific units of the complete system. (1.5 points)
6.4 What is the calcium treatment of steel in secondary steelmaking?
   (Give at least 2 items)  
   \(1.0\) point

6.5 a) Give the equation representing the de-phosphorization reaction of molten steel with lime and give the equilibrium constant for that equation.  
   \(1.0\) point

b) What are the main factors necessary to obtain low phosphorus contents in the finished steel? (Give at least 2 items)  
   \(1.0\) point

6.6 What is cleanliness bubbling (or soft bubbling)?  
   \(0.5\) point
Task 7: Continuous Casting 8 points

7.1 Give the definition for:
   (a) inclusions (0.5 point)
   (b) precipitates (0.5 point)

7.2 Define the term of “Microsegregation” and “Macrosegregation” and give their size range respectively. (2.0 points)

7.3 What is the primary dendrite arm spacing and secondary dendrite arm spacing for equiaxed dendrites? (Make a sketch and mark the PDAS and SDAS in the sketch) (1.0 points)
7.4 It is well known that during continuous casting the mould is oscillating.

a) Please give a typical value of the frequency and amplitude of the mould oscillation, respectively. \( \text{(1.0 point)} \)

b) Describe the term "negative strip time" of mould oscillation and sketch the figure. \( \text{(1.0 point)} \)

c) Give the sketch of the formation of oscillation marks \( \text{(1.5 points)} \)

d) What is the influence of an increasing of “Negative strip time” on the quality of steel cast? \( \text{(0.5 point)} \)