# 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**

**Last name, first name:**          **Register No. (Matrikel-Nr.):**

_____    _____

**Signature:** _____

| Task | Points (max.) | Points | Signature | Approval date | Final points (total) |
|------|------|------|------|------|------|
| 1 | 6 | | | | |
| 2 | 8 | | | | |
| 3 | 8 | | | | |
| 4 | 6 | | | | |
| 5 | 6 | | | | |
| 6 | 8 | | | | |
| 7 | 8 | | | | |
| **Total:** 50 | | | **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
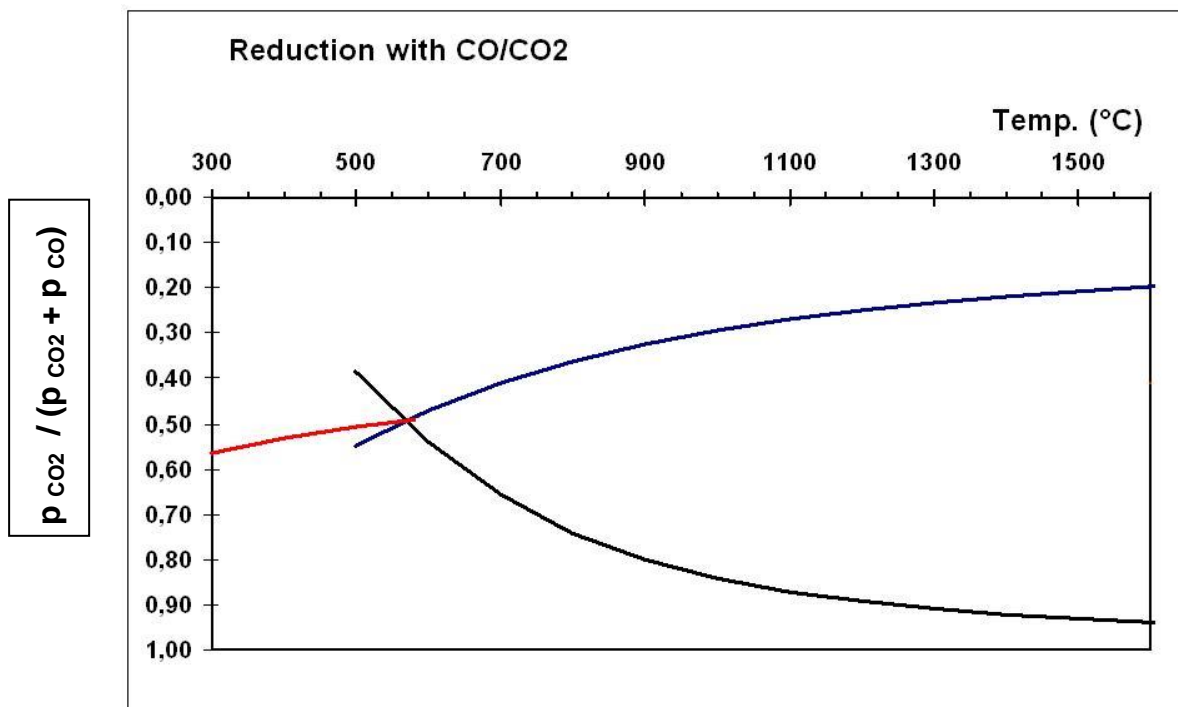
2.1     Give the definitions of the following terms:                    *(1.0 point)*

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)*



Reduction with CO/CO2

(b) Give the temperature and the $CO/CO_2$-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?    *(0.5 point)*

b) What are the advantages and disadvantages of OBM compared to the LD-BOF process?    *(1.0  point)*

3.4    What is the Laval nozzle? (Give the schematic sketch)    *(0.5 point)*

3.5   In which process [N] concentration of liquid raw steel is higher and why?

(a) BOF    (b) EAF    *(1.0 point)*

## Task 4 : Slags and Fluxes                                                 6 Points

4.1   Give equations representing:

    (a) Formation of di-calcium silicate                                *(0.5 point)*

    (b) Slag basicity                                                   *(0.5 point)*

4.2   a) Please sketch the ternary system diagram of $CaO$-$Al_2O_3$-$SiO_2$ at 1600 °C
with equilibrium (or saturation) lines.                          *(1.5 point)*

    b) Draw the line where B1=1 in this ternary system diagram.      *(0.5 point)*

    c) Which point represents the region of particular interest for ladle metallurgy
slag?                                                           *(0.5 point)*

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)                                            *(1.0 point)*

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$^{o}$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, respetively.                                                                 *(1.0 point)*

b) Describe the term "negative strip time" of mould oscillation and sketch the figure.                                                                                                    *(1.0 point)*

c) Give the sketch of the formation of oscillation marks          *(1.5 points)*

d) What is the influence of an increasing of "Negative strip time" on the quality of steel cast?                                                                                        *(0.5 point)*