Rheinisch-Westfälische Technische Hochschule Aachen

# Mastercourse

## Metallurgical Engineering

## (Ferrous Process Metallurgy)

## 2009-10-19

**Last name, first name:**                    **Matrikel-Nr.:**


**Signature:**

| Task | Points (max.) | Points | Signature | Approvaldate | Finalpoints (total) |
|------|------|------|------|------|------|
| 1 | 5 | | | | |
| 2 | 5 | | | | |
| 3 | 5 | | | | |
| 4 | 5 | | | | |
| 5 | 5 | | | | |
| 6 | 5 | | | | |
| 7 | 5 | | | | |
| 8 | 5 | | | | |
| 9 | 5 | | | | |
| 10 | 5 | | | | |
| **Total:** | | | **Total after approval:** | | |


For each correct partial answer: 0,5 points till the maximum reachable number of points

# Mastercourse

## Metallurgical Engineering

**Univ. Prof. Dr.-Ing. Dieter Senk**                                      **2009-10-19**

**1. Task: Pelletizing und Sintering**                                      **5 points**

a)   Complete the diagram of iron ore preparation (figure 1) for blast furnace and direct
     reduction processes.

**2,0 points**
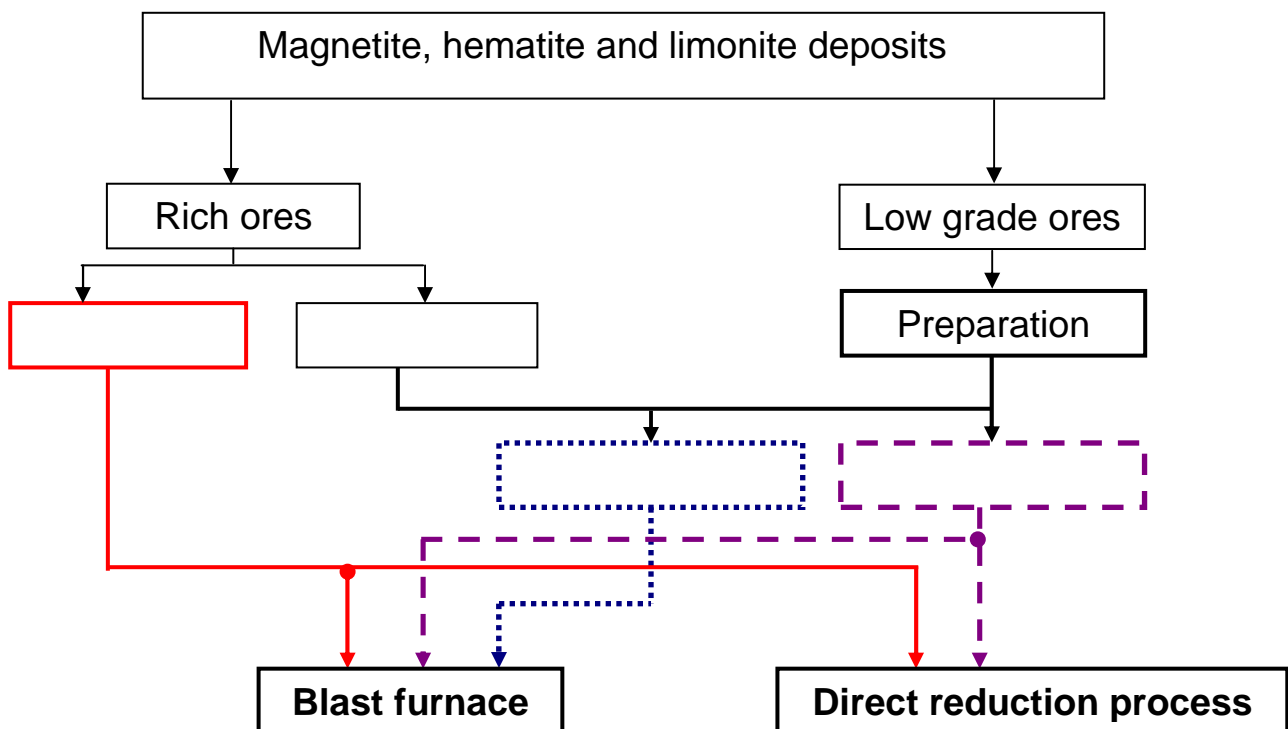


Figure 1

b)   Name at least four components of sintering mixture.

**2,0 points**

c)   What is the grain size of

    1.  Sinter

    2.  Pellets

   for the blast furnace?

**1,0 points**

## 2. Task: Metallurgical Coke                                            5 points

a)

    1. Why is it necessary to cool down metallurgical coke after the coking process?

    2. Name and describe two ways to cool down metallurgical coke.

**2.5 points**

b) What is the average process time of the coking process?

**0,5 points**

c) Give two "disadvantages" of using coke in the blast furnace.

**1,0 points**

d) There are several options to reduce the specific coke consumption in blast furnaces. Name at least two of these options.

**1,0 points**

## 3. Task: Blast Furnace                                                    5 points

a)  In a blast furnace hematite is reduced to metallic iron. Calculate

   1.  the amount of oxygen to be removed in kg per ton of hematite,
   2.  the demand for carbon in kg per ton of hematite, if only direct reduction takes place,
   3.  the demand for carbon in kg per ton of hematite, if 50 % direct reduction and 50 % indirect reduction take place.
   4.  How much metallic iron in kg is produced per ton of hematite?

Given:

$M_{Fe}$ = 56 g/mole, $M_C$ = 12 g/mole, $M_O$ = 16 g/mole,

**3,0 points**

b)  How is blast furnace slag generated? Name at least one task of slag in the blast furnace!

**1,0 points**

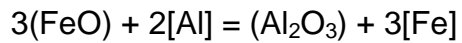c)  What is the "dead man" in the blast furnace? What happens in the "dead man"?

**1,0 points**

## 4. Task: Thermodynamics  5 points

a)  Give the law of Hess.

**1,0 points**

b)  Calculate the reaction enthalpy at 25°C and 1 at m of the reaction:

$3(FeO) + 2[Al] = (Al_2O_3) + 3[Fe]$

The following standard formation enthalpies are given:

$\Delta H°_{298,FeO}$ = -264,84 kJ/mole

$\Delta H°_{298,Al2O3}$ = -1673,6 kJ/mole

**2,0 points**

c)  Calculate the oxygen partial pressure above pure iron oxide and pure iron at 1500°C.

Given:

$(FeO) = [Fe] + ½ \{O_2\}$

$\Delta G^0 = 63500 - 16,8 * T$ [J/mole]

**2,0 points**

## 5. Task: Converter                                                    5 points

a) Name and describe the three main types of steelmaking converters, which are currently industrially applied.

**3,0 points**

b) Give the oxidation order of the elements dissolved in hot metal.

**2,0 points**

## 6. Task: Direct and Smelting Reduction                              5 points

a)

1.  Which product is produced in direct reduction processes and which product is produced in smelting reduction processes?

2.  Name at least four significant differences between these products [1].

**3,0 points**

b)  Name at least two reducing agents for each of the following processes:

1.  direct reduction

2.  smelting reduction!

**2,0 points**

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[1] Who cannot answer task a)1), shall contact the examination supervisor. The corresponding products will be given, with the written comment, that task a)1) was not fulfilled.

## 7. Task: Electric Steelmaking                                     5 points

a) Of which material are the electrodes in AC electric arc furnaces? What are the advantages of the material for this application? (at least 2 advantages)

**1,5 points**

b) 100 tons of scrap are molten down in an EAF with a power of 120 MW. The efficiency of electrical energy during the melting phase amounts 70 %. How long will it take until the100 tons of scrap are completely molten? In this example only electric energy is used. (The needed energy to melt one ton scrap is 375 kWh).

**1,5 points**

c) Why is it necessary to operate a DC electric arc furnace with hot heel?

**0,5 points**

d)

1. Explain the generation of foamy slag in Electric Arc Furnaces.

2. Give at least 2 advantages of operating the Electric Arc Furnace with foamy slag.

1,5 Punkte

## 8. Task: Secondary Metallurgy                                    5 points

a)  Draw a schematical sketch of the RH facility and label the facility parts.

**3,0 points**

b)

1. Give name and equation of the thermo-chemical equilibrium which describes deoxidation of steel melts with carbon.

2. What is the value of the corresponding equilibrium constant at 1600 °C?

3. Describe the changes in the achievable minimum oxygen content, if the pressure above the steel melt is reduced.

**2,0 points**

## 9. Task: Continuous Casting                                    5 points

The strands of a two-strand-continuous caster have the dimensions of 1785 mm by 250 mm and a metallurgical length of 22,20 m. The casting speed is at constantly 0,95 m/min. The density of the liquid steel amounts 7 g/cm³, the density of the solid and hot steel amounts 7,4 g/cm³

a)  Calculate the so-called casting constant k.

**2,5 Points**

b)  How much is the production per year? It is considered that this caster shuts down for 25 full days per year and produces the other time.

**2,5 Points**

## 10. Task: Protection of Environment, Recycling        5 points

a)  Name 3 different sorts of scrap and give a short definition for each of them.

**3,0 points**

b)  Name 4 potentials for the reduction of the specific energy consumption in iron and steel making.

**2,0 points**