# Advanced Master Course

Process Technology of Metals

(Part: Ferrous Process Metallurgy)

Prof. Dr.-Ing. D. Senk

16-10-2008 (8:00-10.00 o’clock)

Hörsaal RS 4 (Rochusstraße 2-4)

(4/2008)

<table>
<thead>
<tr>
<th>Task</th>
<th>Points (max.)</th>
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<th>Signature</th>
<th>Approval date</th>
<th>Final points (total)</th>
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**Total:** 25

**Total after approval:**
Task 1: Pelletizing and Sintering 3 Points

1.1 Pellets production can be divided into 2 distinct stages:
   Stage 1: Green pellet formation
   Stage 2: Heat treatment

   (a) Give one way which can be used for every stage. (1.0 point)
   (b) What is the main function of bentonite in the first stage? (0.5 point)
   (c) Give the range of firing temperature in the second stage. (0.5 point)

1.2 Illustrate the difference between “Acidic sinter” and “Fluxed sinter”. (1.0 point)
Task 2: Blast Furnace 3 Points

2.1 Write the chemical reactions of (a) indirect reduction and (b) direct reduction of iron oxides in blast furnace.  
(1.0 point)

2.2 What is typical temperature and chemical composition of raceway gas?  
(1.0 point)

2.3 What is PCI in blast furnace operation? What is the influence of PCI on the blast furnace process?  
(1.0 point)
Task 3: Oxygen Steelmaking  4 Points

In the converter hot metal is refined to steel. A charge of hot metal (HM) has the following chemical analysis:

<table>
<thead>
<tr>
<th>Element</th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>P</th>
<th>O₂</th>
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<tbody>
<tr>
<td>Mass %</td>
<td>4.45</td>
<td>0.32</td>
<td>0.34</td>
<td>0.12</td>
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<tr>
<td>kg/kmole</td>
<td>12</td>
<td>28</td>
<td>55</td>
<td>31</td>
<td>32</td>
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</table>

Assumptions: At the end of the blowing process the value of each element has to be 0.05%, there is no post combustion.

3.1 Calculate the amount in kg of oxygen per ton of hot metal needed for decarburization and write down the correspondent equations. (1.0 point)

3.2 During burn-off taking place in LD-converter, which element is removed from the melt as the first? Why? (1.0 point)

3.3 What is “manganese hump” during blowing in LD-converter operation? (Illustrate by equation) (1.0 point)

3.4 Draw the burn-off of the elements: C, Si, P, Mn, and S for a converter blowing time of 20 minutes. (1.0 point)
Task 4: Slags and Fluxes 4 Points

4.1 A ternary diagram below is as a slag system composing of CaO-SiO$_2$-Al$_2$O$_3$:

(a) Indicate the slag composition of point A and C. (1.0 point)
(b) Estimate the slag basicity at point B. (0.5 point)
(c) Which point represents the region of particular interest for ladle metallurgy slag? (0.5 point)

![Ternary Diagram](image)

4.2 Which component of a steelmaking slag is increasing the viscosity? (0.5 points)

4.3 What are the tasks of the ladle top slag? (Give at least 2 items) (1.0 point)

4.4 What is the main function of the so-called “Flux material” in iron and steel making? (0.5 points)
Task 5: Electric Steelmaking 3 Points

5.1 What are benefits of foaming slag in electric arc furnace process? (Give at least 2 items) (1.0 point)

5.2 Explain the procedure and also write down chemical reactions for generation of foaming slag in electric arc furnace process. (1.0 point)

5.3 Draw a simple flow chart of the process with input and output materials of the electric arc furnace process. (1.0 point)
Task 6: Secondary Metallurgy (Ladle Metallurgy)  4 points

6.1 What are the tasks of “Secondary Metallurgy” in view of chemical measures and in view of physical measures?  (1.0 point)

6.2 What is the influence of calcium treatment of steel melt in secondary steelmaking? (Give at least 2 factors)  (1.0 points)

6.3 Give the equation representing the de-sulfurization reaction of molten steel with lime and give the equilibrium constant for that equation.  (1.0 point)

6.4 Give the equation which represents the de-oxidation reaction of molten steel with carbon and show schematically the decarburization curves at different atmosphere pressures, (use $P_{CO} = 0.1$ and 1.0 bar).  (1.0 point)
Task 7: Continuous Casting (CC)  4 points

7.1 What are the tasks of continuous casting mould powder? (Give at least 2 items).  

7.2 Describe the term "negative strip time" of mould oscillation. (Sketch the figure and show equation if necessary).  

7.3 What is "Soft Reduction"?  
What is "Liquid Core Reduction"?  

7.4 Classify the size range of "Macro-inclusion" and "Micro-inclusion".  