Master examination

„Steel Design“

20.02.2017

Name, first name:

Matriculation number:

Declaration: I am healthy and able to take part in the examination.

Signature:

Task	Points	Achieved points	Points after review (additional points)
1	6		
2	3		
3	4		
4	7		
5	2.5		
6	8		
7	2.5		
8	4		
9	2.5		
10	3		
11	3.5		
12	4		
Sum	50		

You need 44% to pass the examination.

Task 1 AHSS I 6 Point(s)

In Table 1 there is the chemical composition for different Advanced High Strength Steels. Match the alloying concepts with the following steel groups (HSLA, TRIP, DP) and explain your choice briefly. (6 Points)

Table 1: Chemical composition of AHSS steels (in Mass.-%)

Stahl / Steel	C	Mn	Si	Al	Nb
A	0.2	1.4	1.5	0.04	-
B	0.1	1.0	0.5	0.04	-
C	0.2	1.5	0.1	1.8	-
D	0.07	0.35	0.04	0.04	0.04

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

Task 2 AHSS II 3 Point(s)

Sketch the technical engineering curve of a DP-steel and a HSLA, both with the same ultimate tensile strength, in one stress-strain-diagram. What is the main difference between those two stress-strain curves? How can you explain this difference based on the microstructural features of a DP-steel? (3 Points)

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

Task 3 AHSS III 4 Point(s)

Figures 1 shows 4 different “nano-engineering” concepts for AHSS-steels. The microstructure is either controlled by heat treatment or deformation.

A) Which microstructural features can be identified on the nm-scale? (2 Points)

b) Which microstructural features form during a deformation, which microstructural features form due to a heat treatment? (2 Points)

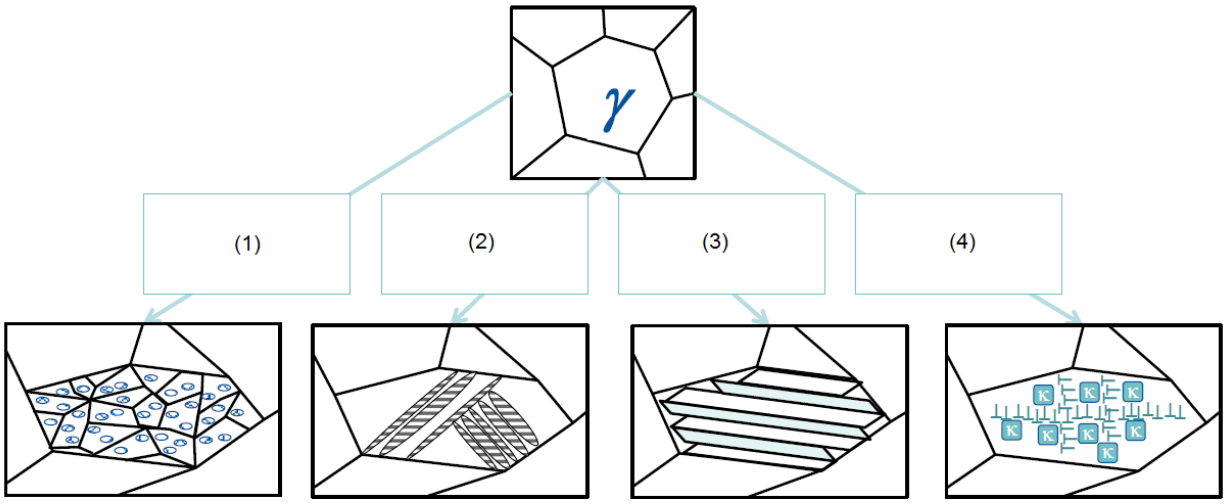


Figure 1: “Nano-engineering” concepts for AHSS

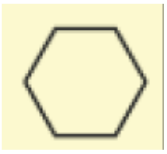
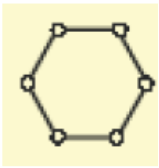
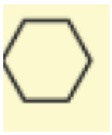
Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

Task 4 construction steels 7 Point(s)

Heavy plates can be produced by conventional hot rolling, normalized rolling or thermomechanical rolling.

a) Point out the difference in the microstructure for the different hot rolling approaches in the table in appendix 1. Therefore, sketch the austenite grain morphology after the last rolling pass, the nucleation seeds for the γ→α phase transformation and the resulting ferrite grain (please consider the grain size as well). (3 Points)

Appendix 1

	Conventional Hot rolling	**Thermomechanical rolling**	**Normalized rolling**
Austenite grain			
Nucleation			
Ferrite grain			

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

b) What is the main difference between i) conventional hot rolling, ii) normalizing rolling and iii) thermomechanical rolling according to the rolling parameter? (1.5 Points)

c) What is the difference in the chemical composition between steels used for conventional rolling and thermomechanical rolling? (1 Point)

d) Which heat treatment is used to produce special high-strength steels which aim for a yield strength of 550 – 1100 MPa? What is the microstructure of these steels? (1.5 Points)

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

Task 5 pipe manufacturing 2.5 Point(s)

Explain the industrial production of longitudinal welded pipes with a large diameter starting from a heavy plate. What is the name of this process? Describe each processing step briefly. (2.5 Points)

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

Task 6 boiler tubes 8 Point(s)

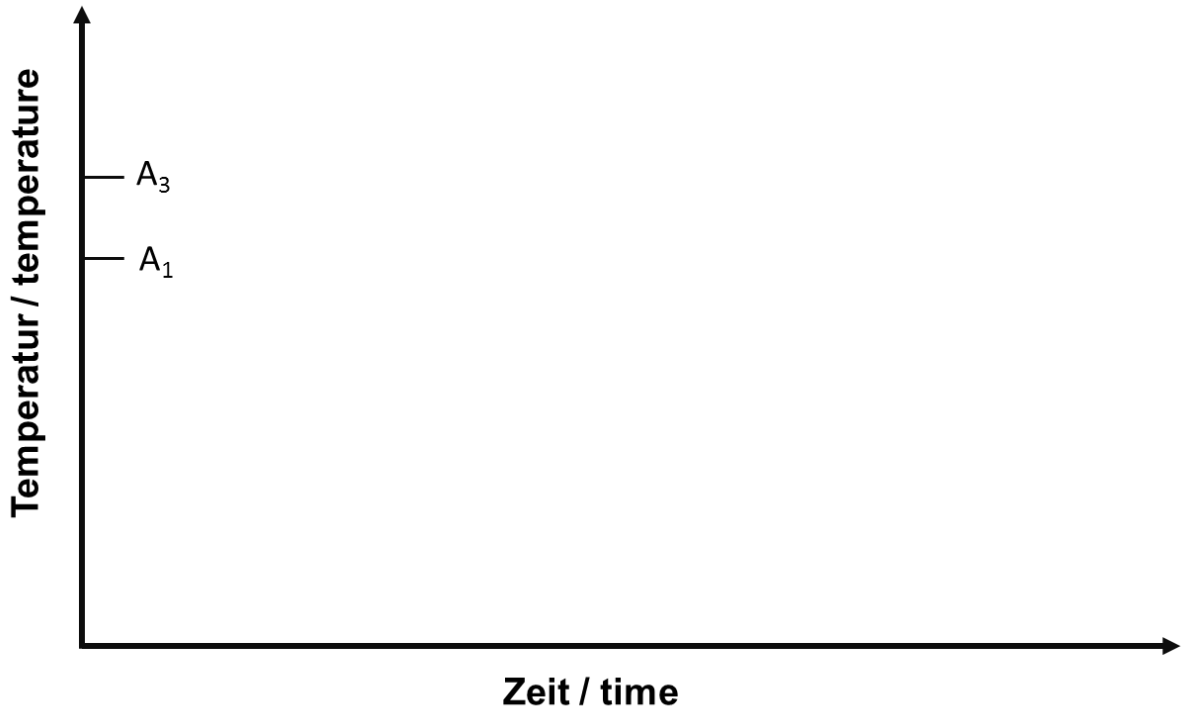
One steel group used as a material for boiler tubes are 9-12% chromium steels.

a) What is the microstructure of modern 9-12% Cr steels? (1 Point)

b) Which problems can occur due to the high Cr addition? What measures can be taken to avoid this problem? (1.5 Points)

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

c) Sketch the heat treatment for these steels in the diagram given in appendix 1. Add the approximate temperature and the microstructure at each step (austenite, ferrite, martensite, bainite, pearlite, tempered martensite). (3.5 Points)



d) Beside ferritic steels two other kind of materials are frequently used for boiler tubes. Name these. (2 Points)

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

Task 7 line pipes 2,5 Point(s)

a) How does a thermomechanical treatment effect the toughness of line pipe steels? (1 Point)

b) Which strengthening mechanisms can be activated by thermomechanical rolling? (1,5 Point)

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

Task 8 precision tubes 4 Point(s)

a) What is the purpose of an “Autofrettage” treatment and how does this treatment affect the microstructure of the steel? (2 Points)

b) For which components is the “Autofrettage” treatment necessary? Explain your answer briefly. (2 Points)

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

Task 9 extra deep drawing steels 2.5 Point(s)

The coils A, B, C and D have been manufactured according to the process parameters listed below. Which of the four coils possesses the best deep-drawability properties? Explain why the other three coils are less suitable for deep-drawing i.e. have worse deep-drawability properties. (2.5 Points)

Process parameters	Coil A	Coil B	Coil C	Coil D
Al in wt% N in wt% acc. to the chem. analysis	0,031 0,0029	0,042 0,0041	0,025 0,0019	0,035 0,0033
coiling temperature (°C)	550	580	570	600
Cold rolling degree of deformation (%)	58%	69%	71%	75%
Recrystallisation annealing (-)	batch annealing	batch annealing	continuous annealing	continuous annealing

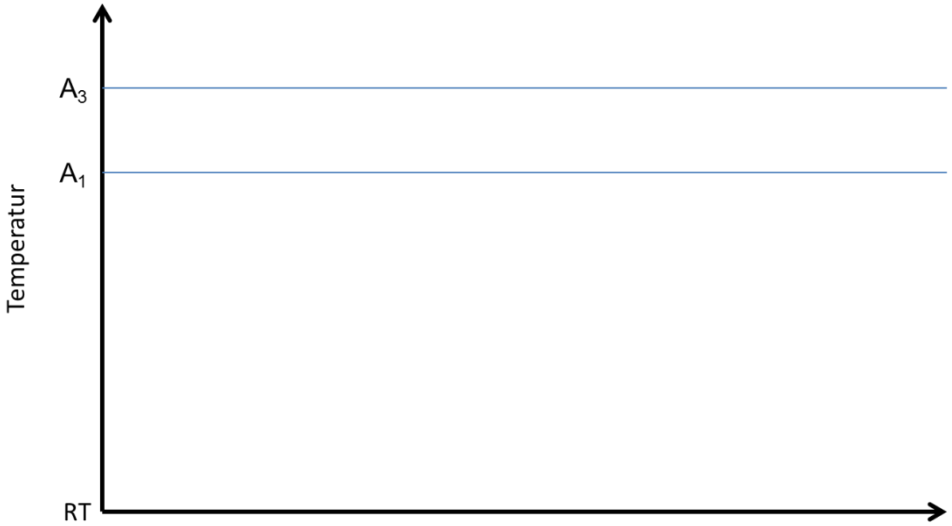
Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

Task 10 special stainless steels 3 Point(s)

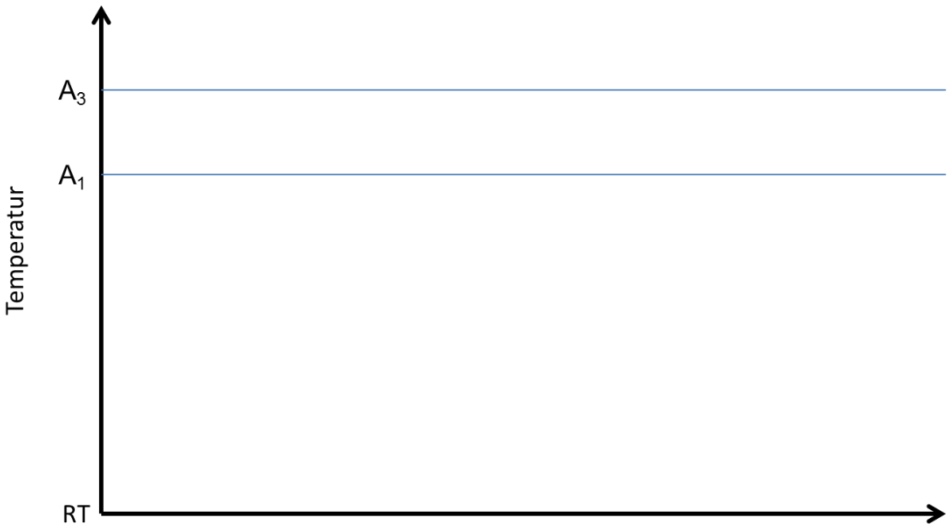
a) Sketch the heat treatment of i) an AFP-steel (Microalloyed ferritic-perlitic steels) and ii) a Q&T steel in the diagrams given in Appendix 1. (2 Points)

Appendix 1

i)



ii)



b) Which of these two steels has a better toughness? (1 Point)

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

Task 11 tool steels 3.5 Point(s)

Tool steels are usually separated into three groups based on their tempering resistance.

a) What are these three groups and what is the temperature limit for their operation temperature? (1.5 Points)

b) Match the curves given in Figure 1 with the tool steel grades described in task a). (2 Points)

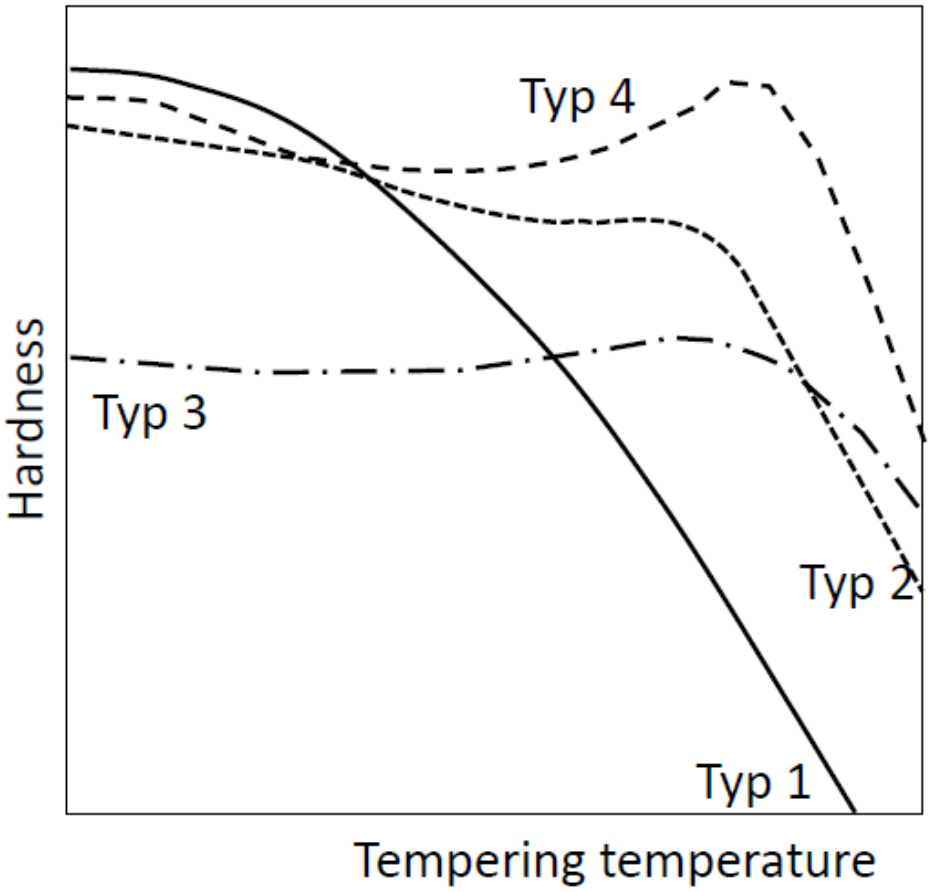


Figure 1: Tempering resistance of different tool steels

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224

Task 12 rail steels 4 Point(s)

Name 4 basic demands on steels used as rail materials. (4 Points)

Head of Department: Univ. Prof. Dr.-Ing. W. Bleck Fon: +49 241 8095782
E-Mail: bleck@iehk.rwth-aachen.de Fax: +49 241 8092224