

Master examination
„Materials Science of Steel – Steel Design“
26.03.2015

Name:

Matrikelnummer:

Signature:

Task	Maximum Points:	Points achieved:	Review: (additional points)
1	1		
2	3		
3	1.5		
4	1.5		
5	1		
6	1.5		
7	5.5		
8	1		
9	1.5		
10	2.5		
11	2.5		
12	0.5		
13	2.5		
14	1.5		
15	3		
Sum	30		

You need 44% to pass the examination.

The examination is divided into three parts which have to be passed separately. The final result is calculated as follows:

37,5 % Written examination (“Materials Science of Steel”)

37,5 % Oral Examination (separate date)

25 % Written examination (“Materials Science of Steel – Steel Design”)

Task 1**AHSS I****1 Point**

Sketch the engineering stress-strain curves of a DP-steel and a HSLA steel and explain the main differences (1 Point).

Task 2**AHSS II****3 Points**

- a) Give the volume fractions of a TRIP, a DP and a HSLA steel in the table given in **Appendix I** and add the average ferrite grain size for these steels (2 Points).

Appendix I:

<u>Microstructure</u>		<u>TRIP</u>	<u>DP</u>	<u>HSLA</u>	<u>DDQ</u>
f, %	α				100
d, μm					10-40
f, %	α'				0
f, %	α_B				0
f, %	γ_R				0

- b) Which of the steel grades mentioned in task a) are HSS and which are AHSS steel grades (1 Point)?

Task 3**AHSS III****1.5 Points**

One of the key features to make use of the TRIP effect is to control the transformation behaviour of austenite to martensite during deformation.

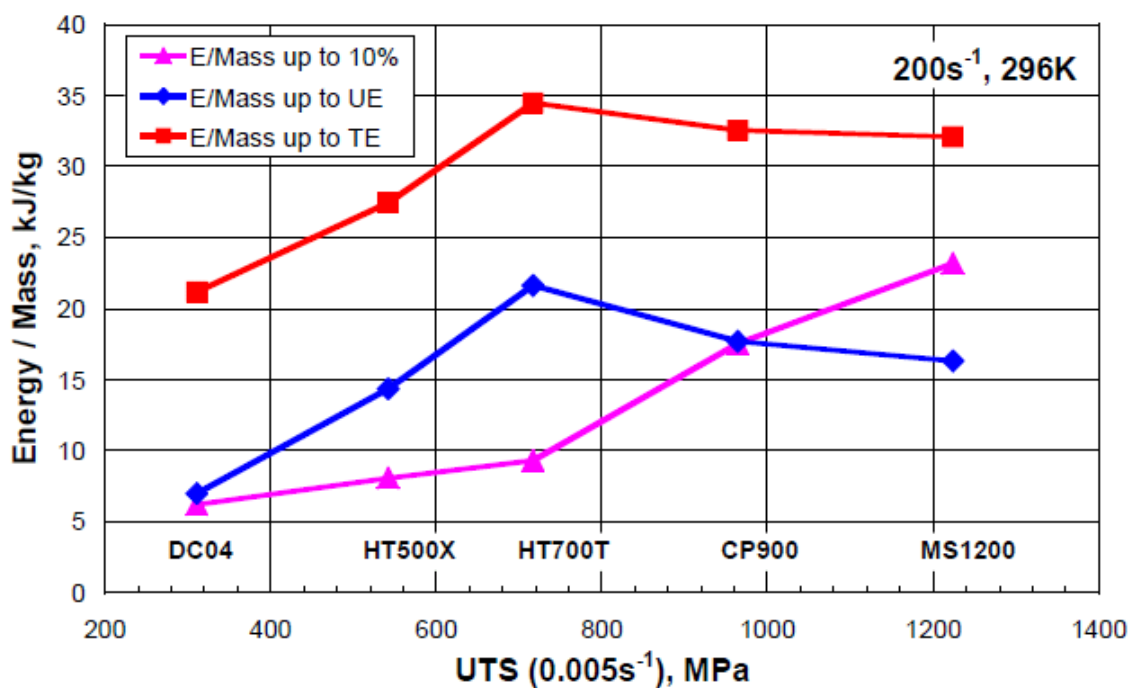
Give a short definition for the following temperatures which are used to describe the stability of austenite (1.5 Points):

- M_s
- $M_{s,\sigma}$
- M_{d30}

Task 4**AHSS IIII****1.5 Points**

In **Appendix 1** the specific energy absorption per mass at a strain rate of 200 s^{-1} is plotted vs. quasistatic tensile strength for different steels.

- Which of these steels absorbs the highest specific Energy (0.5 Points)?
- Which of these steels would you recommend for a B-pillar in a car body?
Explain your choice (1 Point)

Appendix 1

Task 5

rail steels I

1 Point

What is the typical C content and the microstructure of a conventional rail (1 Point)?

Task 6

rail steels II

1.5 Points

- a) What is the maximum rolling length of the rails nowadays? (0.5 Points)
- b) Which measures do you know to reduce the surface wear of rails (1 point)?

Task 8**tube steels I****1 Points**

One way to manufacture tube steels is using pilger rolling. Name one advantage and one disadvantage of pilger rolling (1 Point).

Task 9**tube steels II****1 Point**

Pipe manufacturing can be separated in the following two different techniques: i) welded pipes and ii) seamless pipes. Explain the main difference between seamless and welded pipes briefly. Consider the maximum wall thickness, the maximum diameter and wall thickness/diameter ratio (1,5 Point).

Task 10**line pipe steels****2.5 Points**

- a) After casting line pipe are commonly thermomechanical rolled. Which strengthening mechanisms lead to the strength of the thermomechanical treated material (1 Point)?
- b) Which processing method is carried out to form the pipe before longitudinal welding (0.5 Points)?
- c) Which treatment is carried out after the welding? What is the purpose of this treatment (1.0 Point)?

Task 11**boiler tubes****2.5 Points**

- a) Name two requirements on steels used for boiler tubes (1 Points)
- b) Sketch the time-temperature profile for the heat treatment of ferritic-martensitic steels which are used as boiler tubes. Name all process steps and indicate the A_{c1} - and A_{c3} -temperature (1.5 Points).

Task 12**EDDS I****0.5 Points**

Which automotive body part has the highest requirements according to deep drawing? Give a short explanation (0.5 Points)

Task 13**EDDS II****2.5 Points**

Four different coils A, B, C and D have been manufactured using different processing parameters. Which coil is most suitable for deep drawing applications? Give an explanation for the remaining coils, why they are not suitable (2.5 Points).

Processing parameters	Coil A	Coil B	Coil C	Coil D
Wt.-% Al	0,035	0,021	0,039	0,026
Wt.-% N	0,0033	0,028	0,0039	0,0027
Coiling temperature (°C)	600	550	580	570
Cold rolling degree (%)	75%	58%	59%	69%
Kind of annealing treatment (-)	Continuous annealing furnace	Batch annealing furnace	Continuous annealing furnace	Batch annealing furnace

Task 14 **special alloyed and stainless steels** **1,5 Points**

Name at least 3 demands on the base material of gear materials (1.5 Points)

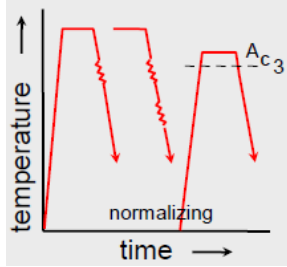
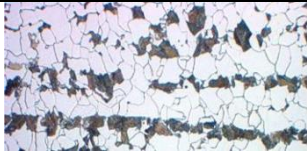
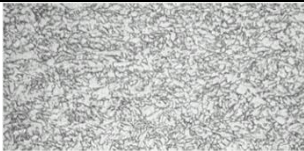

Task 15

construction steels

3 Points

a) **Appendix 1** shows different production techniques to manufacture high-strength special structural steels plates. Add the name of the processes which are missing and sketch the according time-temperature-schedule (2 Points).

Appendix 1

<i>process</i>	<i>normalizing, normalizing rolling (N)</i>		
<i>treatment</i>			
<i>microstructure</i>			
<i>yield strength</i>	<i>275 - 460</i>	<i>350 - 690</i>	<i>550 - 1100</i>
<i>steel grade</i>	<i>ship building steels weathering steels offshore steels cold forming steels</i>	<i>ship building steels offshore steels pipe steels</i>	<i>wear resistant special structural steels high-strength special steels</i>

b) Which alloying elements beside C and Mn are necessary to manufacture high-strength water-quenched steels with martensitic microstructure and large sheet thickness? Explain your choice briefly (1 Point)?

