

Master examination

„ Steel Design“

30.03.2017

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	3		
2	7		
3	3.5		
4	5		
5	2		
6	5		
7	1.5		
8	1		
9	3		
10	4		
11	5		
12	3		
13	3		
14	4		
Sum	50		

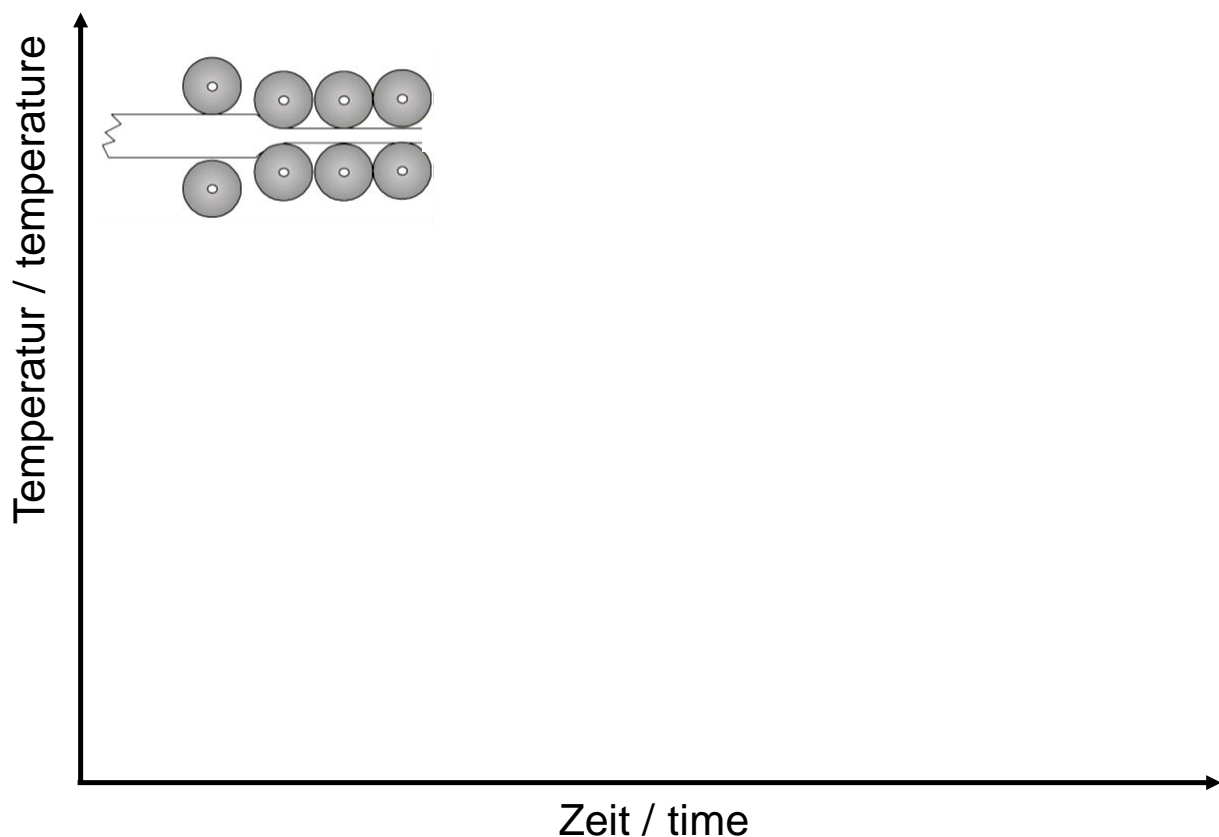
You need 44% to pass the examination.

Task 1**AHSS I****3 Point(s)**

Mechanical properties of advanced high strength steels (AHSS) are frequently correlated with the microstructural features. Name at least three analytic approaches to detect austenite in TRIP steels. Explain for each approach how a separation between austenite and ferrite can be drawn, briefly. (3 Points)

Task 2**AHSS II****7 Point(s)**

- a) Sketch the industrial heat treatment (starting from the last hot rolling pass) for hot rolled i) DP and hot rolled ii) TRIP steels in the given time-temperature diagram in **Appendix 1**. Add the regions for ferritic, bainitic and martensitic phase transformations. (2.5 Points)
- b) Quantify the phase constituents after representative steps during the processing (including the microstructure after the last hot rolling pass). What is the volume fraction of each phase for the TRIP and the DP steel at room temperature? (2.5 Points)
- c) Explain how it is possible to have retained austenite present in a 0.2 wt.-% C steel. Is the retained austenite thermodynamically stable? Is it mechanically stable? (2 Points)

Appendix 1

Task 3**AHSS III****3.5 Point(s)**

Based on the targeted mechanical properties different kind of AHSS steel have better mechanical properties.

Complete the given chart. (3.5 Points)

Steel	DP	CP	TRIP
Microstructure	α, α_M		$\alpha_B, \alpha, (\alpha_M), \gamma_R$
Yield strength			
Hole expansion ratio			

Microstructure: α_B bainite, α_M martensite, α ferrite, γ_R retained austenite

Yield strength: += high, 0 = low

Hole expansion ratio: + = good, 0 = moderate

Task 4**AHSS IV****5 Point(s)**

- a) There are different mechanisms of plastic deformation that may be activated in high Manganese-steels. Name three of them and explain them briefly. (3 Points)
- b) Which physical value determines the forming mechanism? In which unit is it measured? (2 Points)

Task 5**construction steels****2 Point(s)**

Why is the treatment of the crude steel in the secondary metallurgy and especially the treatment of the sulfide shape of great importance for the production of heavy plates?
How is the sulphide shape typically modified? (2 Points)

Task 7 **pipe manufacturing I** **1.5 Point(s)**

What are the process steps in the production of longitudinal seam-welded pipes after casting? (1.5 Points)

Task 8**pipe manufacturing II****1 Point(s)**

One way to manufacture tube steels is using pilger rolling. Name one process-related disadvantage of the pilger rolling process? What is a huge advantage of this process?

(1 Point)

Task 9**Oil Country Tubular Goods (OCTG)****3 Point(s)**

Figure 1 shows a test procedure for the mechanical-chemical properties of OCTG (Oil Country Tubular Goods) steels.

Figure 1



- a) The resistance against which failure mechanism is investigated with this test procedure? (1 Point)
- b) What are the two preconditions that this failure mechanism can occur in OCTG-steels? (2 Points)

Task 10**precision tubes****4 Point(s)**

To increase the service life time of precision tubes an “Autofrettage” treatment can be carried out.

- a) What is the physical principle of an “Autofrettage” treatment? Make a sketch to explain your answer. (2 Points)

- b) A precision tube has a wall thickness of $t=0.5\text{mm}$, a mean diameter of $d=5\text{mm}$ and a yield strength of 800 MPa . Is an inside pressure of 800 bar ($1\text{ bar} = 10^5\text{ Pa}$) sufficient for an “Autofrettage” treatment? (2 Points)

Hint: Barlow's formula relates the internal pressure that a tube can withstand to its dimensions and the strength of its material.

$$\sigma = \frac{p \cdot d_m}{2t}$$

p = inside pressure, d_m = mean diameter of the tube, t = wall thickness, σ = equivalent stress.

Task 11**boiler tubes****5 Point(s)**

- a) The construction of a steam generator requires boiler tubes with adequate properties. Which physical and chemical conditions can damage boiler tubes in service? (2 Points)
- b) One target of material development for boiler tubes is a higher creep strength. Which alloying elements are used to increase the creep resistance of ferritic-martensitic and ferritic-bainitic boiler tube steels? Name at least two. (2 Points)
- c) Which alloying element is added to increase oxidation resistance? (1 Point)

Task 12 **special alloyed steels** **3 Point(s)**

Name three typical demands on the base materials of gear wheels. (3 Points)

Task 13**rail steels****3 Point(s)**

- a) Which two microstructures are used for rail steels? (1 Point)
- b) Some rail steels are improved with head-hardening. How does this treatment affect i) the final microstructure and ii) how does it alter the mechanical properties? (2 Points)

Task 14**tool steels****4 Point(s)**

- a) Name at least 2 reasons why tool steels are tempered. (2 Points)
- b) What should be considered according to the tempering temperature? (1 Point)
- c) Give a short explanation why tool steels are tempered several times instead of tempering them once for a long time. (1 Point)