Master Met. Engineering

„Material Science of Steel“ Part I

25.02.2014

Name:

Matrikelnumber: **Signature:**

Part	Question	Number of points:	Reached score:	Review: (additional points)
1 (70P.)	1	5.0		
	2	3.0		
	3	5.5		
	4	4.5		
	5	5.0		
	6	4.0		
	7	3.5		
	8	3.0		
	9	8.0		
	10	5.0		
	11	6.5		
	12	5.0		
	13	4.0		
	14	1.5		
	15	2.0		
	16	2.5		
	17	2.0		
		∑70		
2 (30P.)	18-28			

You need 44 points to pass the exam.

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Task 1 Thermo mechanical rolling 5.0 Points

Microalloying elements influence several metallurgical phenomena during the thermo mechanical treatment.

a) List and explain the phenomena that are influenced due to the microalloying elements (2 Points)?

b) Which are the mechanisms which are the most important strengthening mechanisms in

- Nb-microalloyed
- V-microalloyed

steels. Name the process step in which the microalloying elements precipitate. What is the impact of the precipitations on the toughness (3 Points)?

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Task 2 Thermo mechanical rolling 3.0 Points

Draw schematically the development of the grain size in dependence of the austenitization time for microalloyed steels for three different temperatures: 950°C, 1050°C and 1150°C and explain the run of the curves (3 Points).

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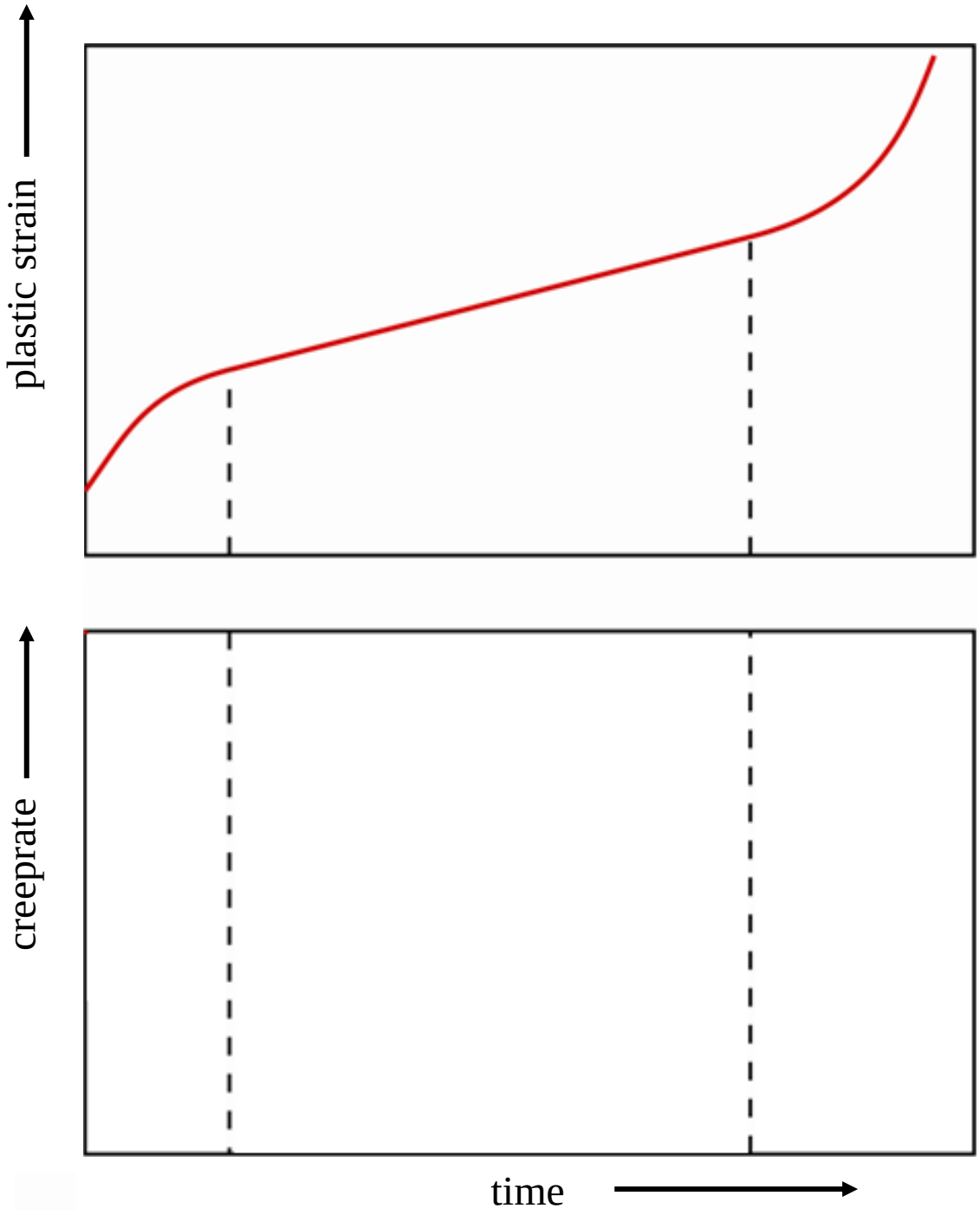
Task 3 Technical Heat treatment 5.5 Points

a) There are three parts in which a creep curve is divided in. Label these in the upper diagram, mark the breakdown point and the stationary creeprate (1.5 Points).

b) Explain the change of creeprate using the lower diagram. Please explain Norton's creep power law to stationary creep (stress dependency) (1.5 Points).



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c) A high creep resistance can be achieved with a small stacking fault energy (SFE) and a small self diffusion coefficient. Which microstructure (fcc or bcc) is more favorable for high temperatures usage? Please explain why high stacking fault energy reduces the creep resistance *(1 Point).*

d) Complete the given chart *(1.5 Points)*.

Parameter on Creep resistance	**Creep resistance …**
high SFE	… is lowered
small self diffusion coefficient	… is increased
finer grain size	
high shear modulus	
hard particles	

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Task 4 Microstructure setting 4.5 Points

a) Name three typical mechanical-technological properties (strength, toughness) that are influenced by the grain size and list them in the given table (3 Points).

b) Add the influence of a smaller grain size on the specific property (1.5 Points).

mechanical-technological property	small grain size
1.	
2.	
3.	

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Task 5 Tensile test 5.0 Points

The maximum force in a performed test cannot directly be connected to a certain point on a true stress- true strain- diagram. This maximum force can be used to indicate the necking of the material. The Considère-criteria can be used to estimate the uniform elongation.

a) Derive the equation for the Considère-criteria, which can be used to determine the uniform elongation *(3 Points).*

b) Draw the Considère-criteria *(2 Points).*

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Task 6 Tensile test 4 Points

Tensile tests are a common method to estimate the mechanical property of metals.

a) Explain the difference between a technical stress-strain diagram and a true stress- true strain diagram (*2 Points*).

b) Draw a technical stress-strain diagram and mark the necessary area to calculate the true stress- true strain diagram. Give a short explanation (*2 Points*).

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Task 7 Sheet testing 3.5 Points

a) Give a short definition for the “perpendicular anisotropy” using the equation of the r-value. Explain the experimental determination of the averaged anisotropy r_m and give the equation for the calculation of the planar anisotropy Δr (2.5 Points).

b) Which material is more favorable for dreep drawing?

Material 1 with

- $r < 1$

Material 2 with

- $r > 1$.

Give a short explanation (*1 Point*).

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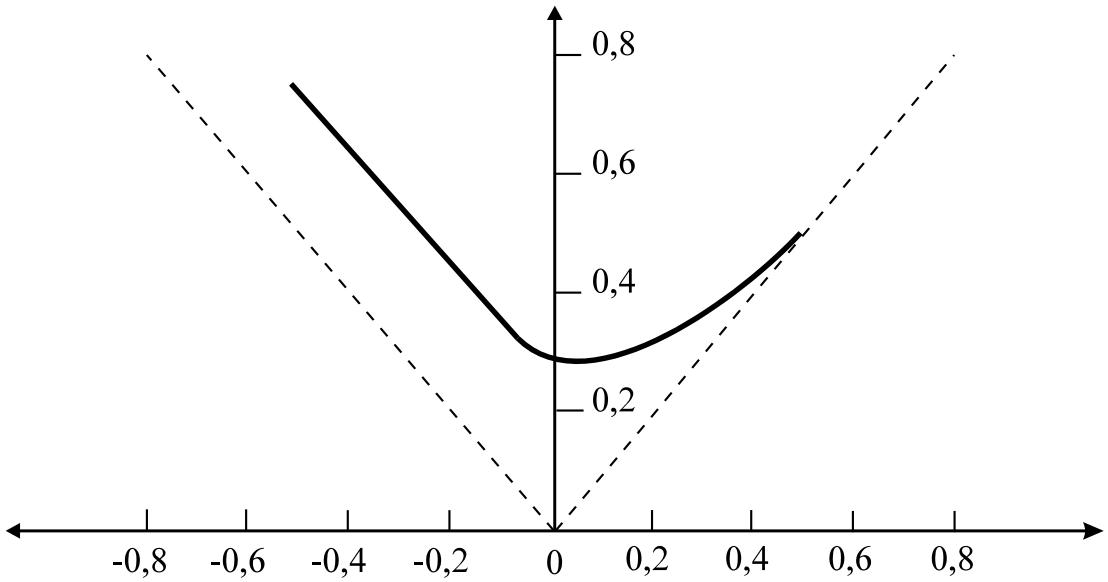
Task 8 Material testing 3 Points

The cold formability of sheet metal can be described with forming limit diagrams.

a) Label the axes of the diagram in **Figure 1** and mark the characteristic strain cases (*2 Points*).

Figure 1:



b) How does an increased sheet thickness or a higher strength change the position of the curve (*1 Point*)?

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Task 9 Fracture mechanisms 8 Points

a) Give a short definition of brittle fracture, ductile fracture, cleavage fracture and shear *(4 Point*).

b) Explain the different topography of cleavage and shear fracture surfaces performing SEM analysis *(3 Points).*

c) Name the different types of cleavage fracture (*1 Points*).

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Task 10 Fracture mechanics 5 Points

a) Describe the difference between the fracture-mechanics properties stress intensity factor and fracture toughness (*2 Points*).

b) Which idealised material behaviour can be used to estimate the critical fracture toughness K_{IC} *(0.5 Points)*?

c) Name two fracture mechanic values which are valid for every kind of material behaviour. Give the boundary conditions and the equations to convert the K-value into J-values *(2.5 Points).*

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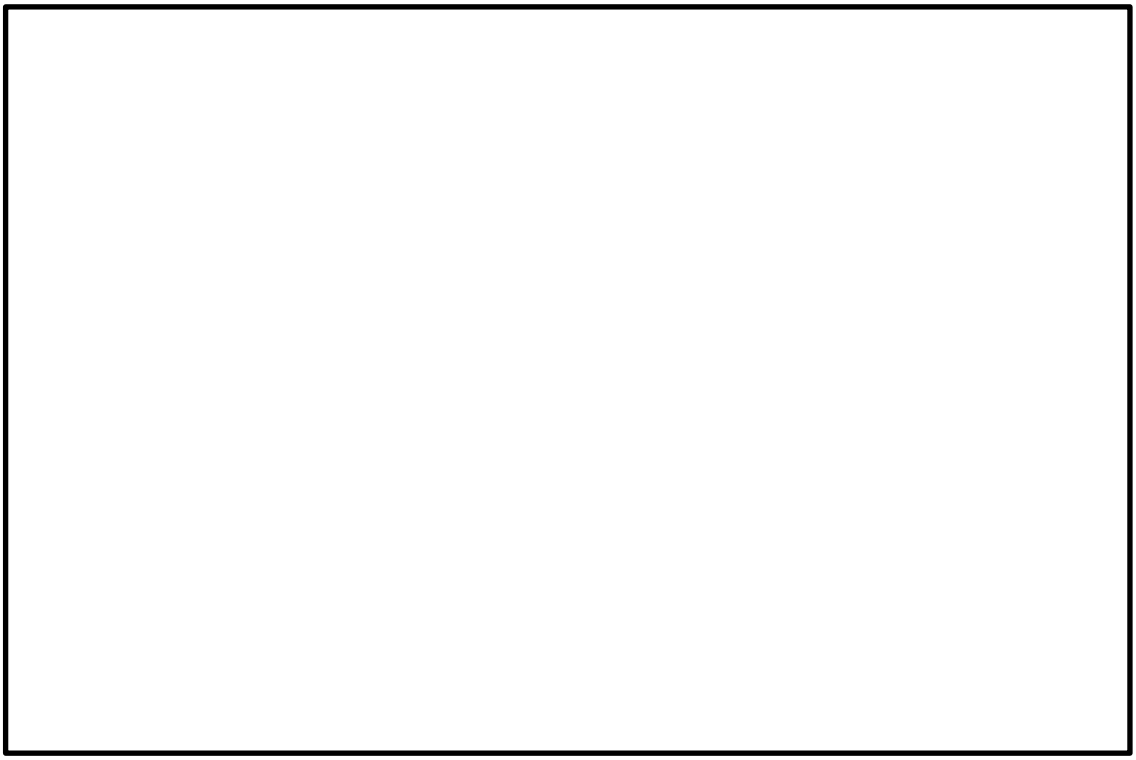
Task 11 Cyclic loading 6.5 Points

a) Draw a Woehler line (s-n-diagramm for cyclic loading) in the diagram and label the axes and mark the three typical areas in the same diagram *(3.5 Points)*



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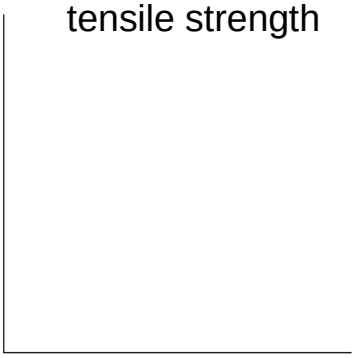
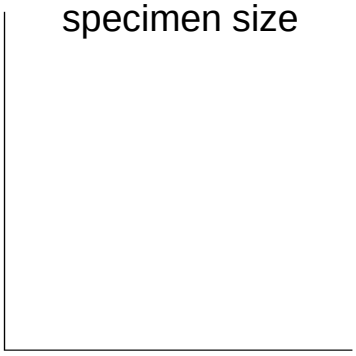
b) Show within the given diagrams the influence of the following parameters on the Woehler line: ultimate tensile strength, size of the specimen, temperature, notch effect, corrosion and shot peening (e.g. with/without corrosion, high/low temperature) *(3 Points).*

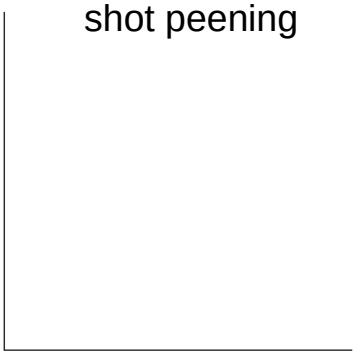
tensile strength



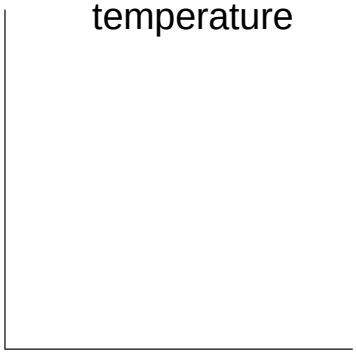
specimen size



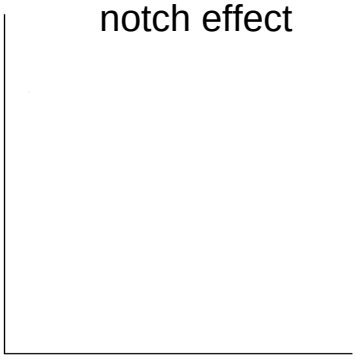
shot peening



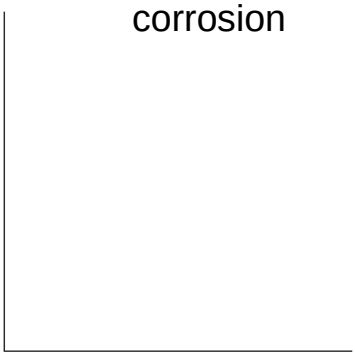
temperature



notch effect



corrosion



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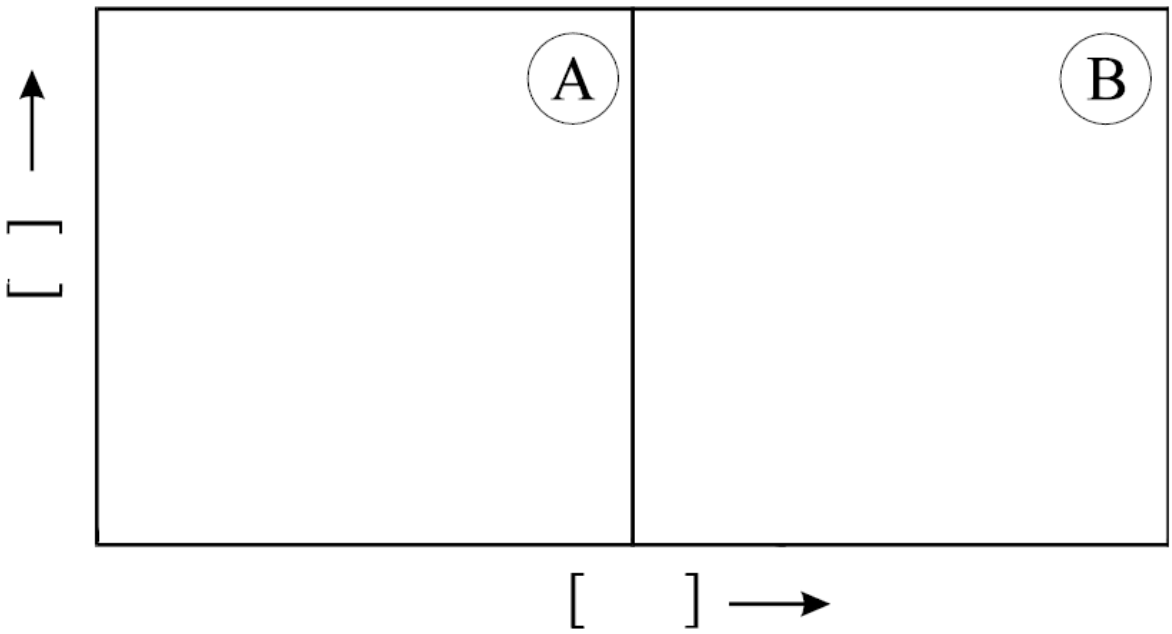
Task 12 Impact testing 5 Points

Draw a typical diagram including axis description *(1 Point)* of an instrumented Charpy-test for a specimen that shows:

a) ductile behavior *(1 Point)*.

b) ductile and brittle fracture (*1 Point*).



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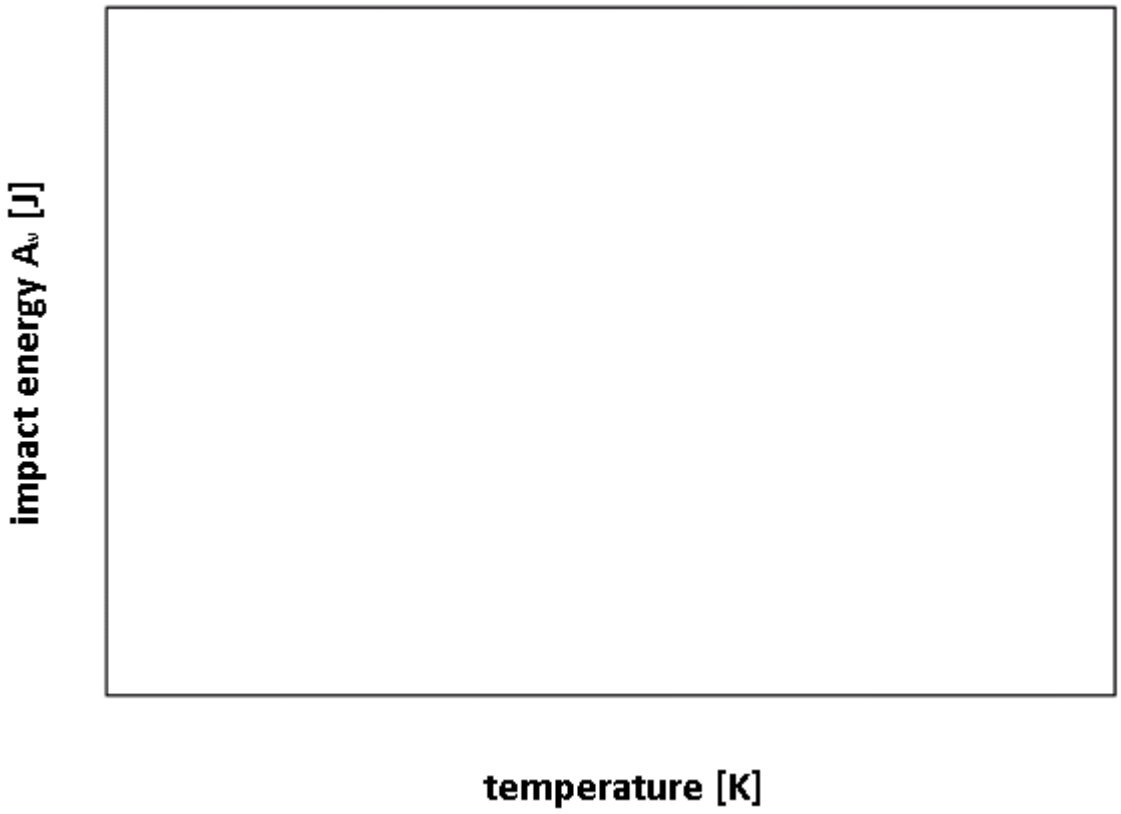
c) Draw a notch impact energy- temperature curce for a Charpy-V, Charpy-U and an impact specimen without notch *(1.5 Points)*.



d) Which of these three specimens should be used for brittle materials *(0.5 Points)*?

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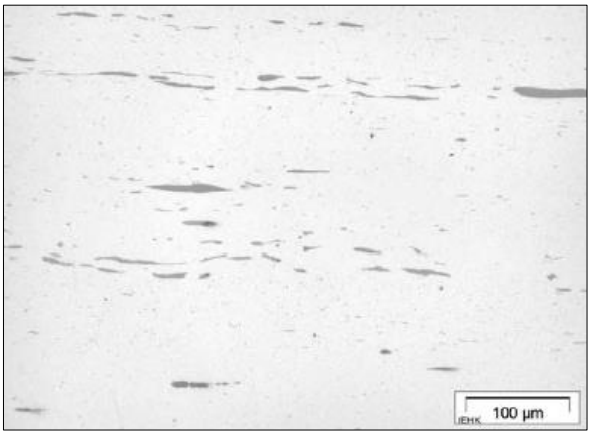
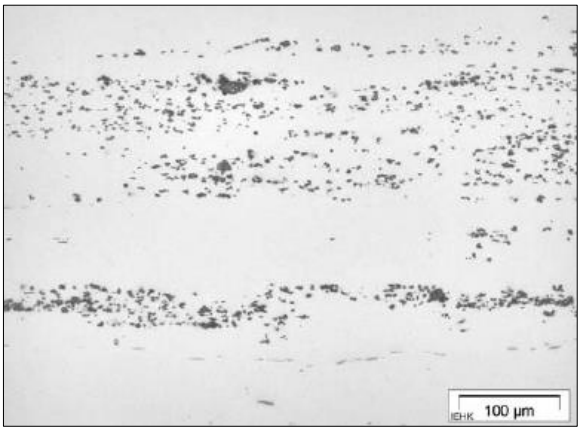
Task 13 Metallography 4.0 Points

a) Metallography can be used to analyze non-metallic inclusions. The pictures in appendix 1 show different kinds of non-metallic inclusions in steel after cold rolling. One picture is showing manganese sulfides and the other aluminum oxides. Assign the given pictures and explain briefly (*2 Points*)!

Appendix 1:



a



b

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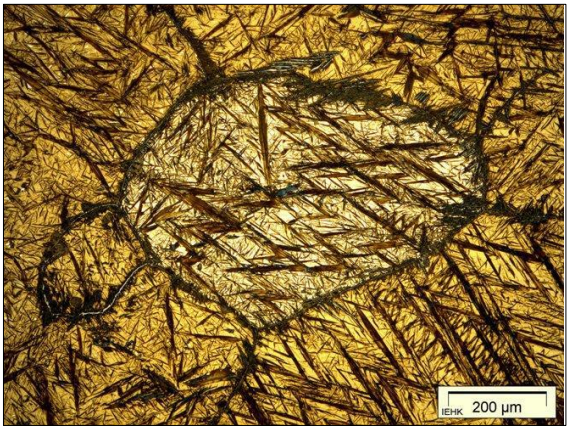
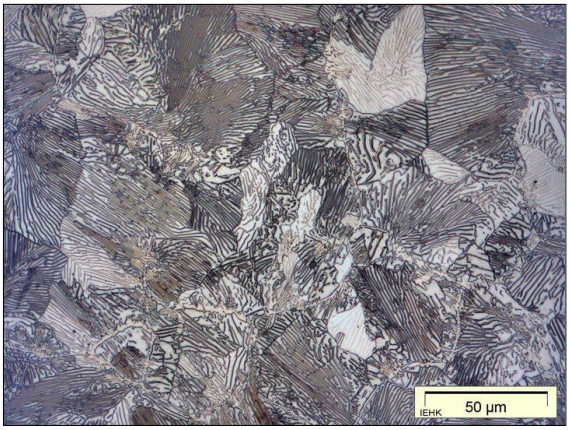
b) Please name the two different microstructures in appendix 2. Can you conclude the carbon content from figure b? Please explain briefly *(2 Point).*

Appendix 2:



a



b

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Task 14 Electron microscopy 1.5 Points

You want to analyze NbC (size approximately 10 nm) and storage of dislocations. Which kind of microscope do you use? Which method is used? *(1.5 Points).*

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Task 15 Dilatometer 2.0 Points

Dilatometer are used to estimate the transformation temperatures in steel. Explain the principle of measurement of a Dilatometer *(2 Points)*.

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Task 16 Jominy test 2.5 Points

a) The hardenability of steels is characterized using Jominy tests. Please give a rough explanation of this kind of testing (including the specimen geometry and evaluation) *(2 Points)*.

b) What is the influence of the alloying elements Cr, Mn und Mo on the hardenability of steel *(0.5 Points)*.

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Task 17 Dislocations 2.0 Points

Explain the Portevin-Le-Chatelier effect. Under which circumstances does this affect appear (*2 Points*)?

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