

Master examination
„Materials Science of Steel -
Steel Design“
31.03.2016

Name:

Matriculation number:

Signature:

Task	Points:	Points achieved:	Points after review (additional Points)
1	3		
2	3		
3	4.5		
4	2		
5	3		
6	4.5		
7	3		
8	5		
9	4		
10	3		
11	3		
12	2		
13	3		
14	5		
15	2		
Sum	50		

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

3 Point(s)

Figure 1 shows different process routes to produce AHSS steels. Add the name and the strip thickness after casting for each of the given process routes. (3 Points)

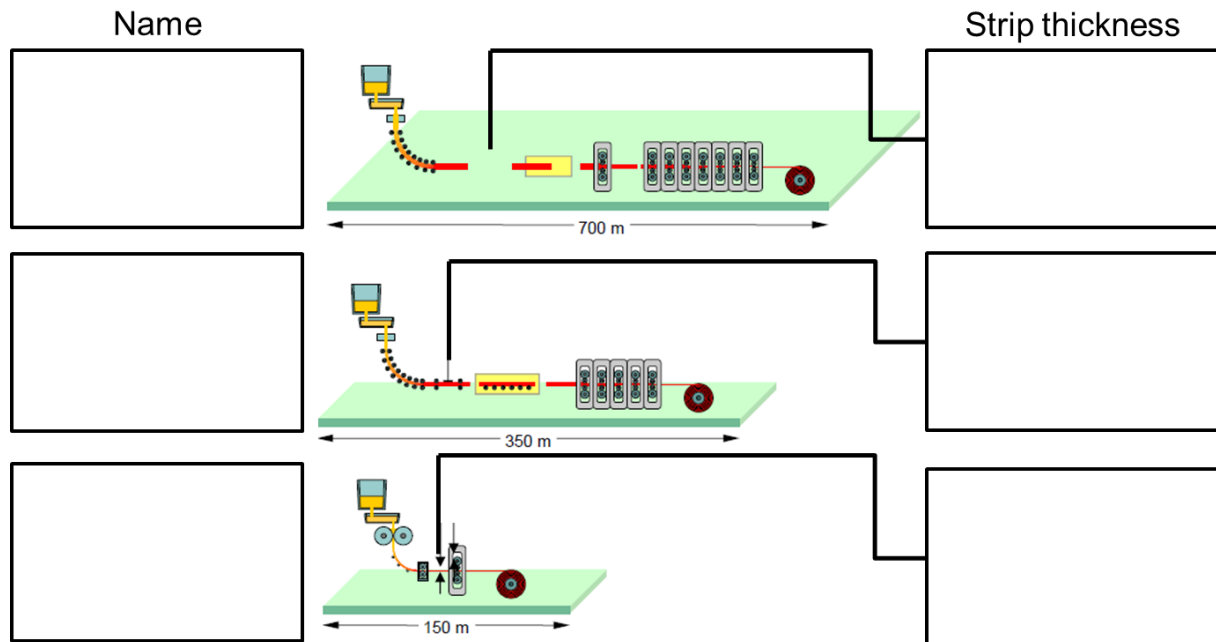


Figure 1

Task 2**AHSS II****3 Point(s)**

Explain the difference between statistically stored dislocations SSD and geometrically necessary dislocations **GND**. Discuss the influence of the GND on the specific behavior of DP steel in the tensile test. (3 Points)

Task 3**AHSS III****4.5 Point(s)**

Complete the given chart. (4.5 Points)

Steel	DP	CP	TRIP
Microstructure			
Yield Strength			
Hole expansion			

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

Hole expansion ratio: + = good, 0 = moderate

Yield ratio: += high, 0 = low

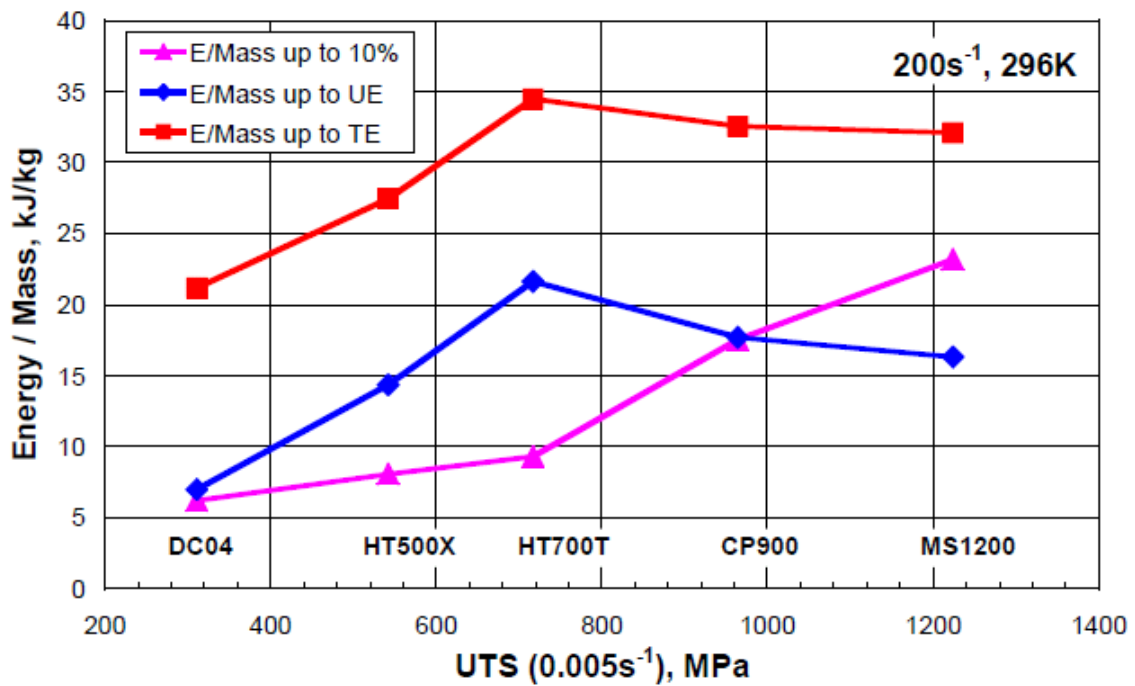
Task 4**AHSS IV****2 Point(s)**

A low-alloyed steel with 0.2 wt.-% C is intercritically annealed.

- a) Explain the term “partitioning”, which is taking place during this intercritical annealing treatment? (1 Point)
- b) After intercritical annealing the steel is quenched. Which microstructure can be observed after quenching? How is the distribution of C? (1 Point)

Task 5**AHSS V****3 Point(s)**

In Appendix 1 there is the specific energy absorption per mass at 200 s^{-1} and room temperature vs. quasistatic tensile strength.

Appendix 1

- a) Which of these steels absorbs the most Energy/Mass (1 Point)?

- b) Which of these steels would you recommend for a B-pillar? Explain your choice (2 Points)

Task 6**AHSS VI****4,5 Point(s)**

Figure 1 shows a microstructure formation which causes superior mechanical properties for AHSS 2nd generation.

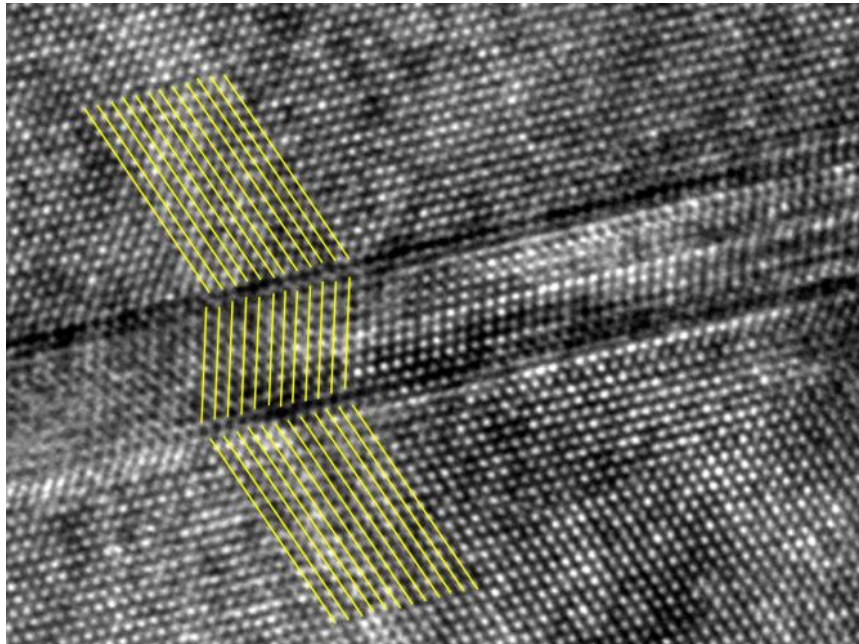


Figure 1

a) Which microstructure formation can be seen in Figure 1? (1 Point)

- b) Which alloying element is detrimental that this microstructure formation can be observed in AHSS steels of the 2nd generation? What is the mass fraction of this alloying element in these AHSS 2nd generation steels? What is the microstructure of these steels? (1.5 Points)
- c) Which physical value determines if this microstructure formation occurs during deformation? In which unit is it measured? (2 Points)

Task 7**Structure Steel****3 Point(s)**

- a) Which alloying element in steels provides excellent ductility at high yield stress, even at extremely low temperatures down to -196°C ? (1 Point)
- b) What is its typical alloying content? What is the typical application field of such heavy plates (2 Points)?

Task 9**Tube Steels I****4 Point(s)**

- a) Match the following tube steel grades with the chemical compositions given in Table 1 and explain your choice briefly: (3 Points)
- i) Welded line pipes (TM rolled)
 - ii) Ferritic martensitic steel for boiler tubes in power plants
 - iii) Austenitic alloys for superheater materials

Table 1: maximum mass.-% of steels used for tubes

Steel	C	Si	Mn	Cr	Mo	V+Nb+Ti	Ni	Other
	0.04	0.75	2	18	3	-	14	N 0.18 + B
	0.09	0.28	1.6	-	-	0.035	-	-
	0.23	0.5	1	12.5	1.2	0.5	0.80	-

- b) Name one alloying element which improves the oxidation resistance and one alloying element which increases the creep resistance of ferritic-bainitic steels for pipes used in steam collectors. (1 Point)

Task 10**Tube Steels II****3 Point(s)**

Large quantities of seamless and longitudinal welded pipes are finally cold formed with either cold pilger rolling or cold drawing.

- a) Name at least two objectives of this final cold forming process. (2 Points)
- b) Name one disadvantage and one advantage of the (hot & cold) pilger rolling process (1 Point)

Task 11**OCTG Steels****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 12**Line Pipes****2 Point(s)**

Line pipe steels often require a resistance against hydrogen induced cracking (HIC). Add at least 2 metallurgical concepts in table 1 to avoid the crack initiation and 2 metallurgical concepts the crack propagation for Line Pipe steels. (2 Points)

Background	Metallurgical concepts
Avoidance of crack initiation (nucleation sites)	
Avoidance of crack propagation	

Task 13 **special and stainless steels** **3 Point(s)**

Stainless steels can be separated into different groups based on their microstructure. Indicate in table 1 the microstructure that you expect for the following stainless steels (ferritic, austenitic, martensitic, pearlitic, ferritic + austenitic Duplex). Explain the reasons for your choice. (3 Points)

Table 1

Microstructure	C	Cr	Mo	Ni	Cu	N	other
	0,01 – 0,03	16,5 – 21,0	0,1 – 5,0	8,0 – 26,0	0 – 2,0	0,02 – 0,25	Ti/Nb: 5/10 x C
	0,01 – 0,05	21,0 – 28,0	0,1 – 5,0	4,5 – 8,0	0,1 – 3,5	0,05 – 0,30	W: 0 – 1,0
	0,06 - 1,10	12,0 – 17,0	0,1 – 2,0	0 – 2,5	-	-	-

Task 14 **Deep drawing steels** **5 Point(s)**

Four different coils A, B, C and D have been processed using parameters given in Table 1. Which coil has the best deep-drawability? Give a short explanation why the remaining three coils have worse deep-drawability. (5 Points)

Processing parameter	Coil A	Coil B	Coil C	Coil D
Al-mass.-%	0,039	0,026	0,021	0,035
N-mass.-%	0,00039	0,0027	0,028	0,0033
Coiling temperature (°C)	580	570	550	600
Cold rolling degree (%)	69%	69%	58%	75%
Annealing furnace for recrystallization treatment (-)	Continuous annealing line	Batch furnace	Batch furnace	Continuous annealing line

Task 15

Rail steels

2 Point(s)

What are the required properties for rail steels? Name at least 4! (2 Points)