Chalmers *Kursnr.: MMK072*
Material och tillverkningsteknik

Exam in Material och tillverkningsteknik-Z, May 28th, 2010

Examiner: Uta Klement (772 1264)
and Antal Boldizar (772 1314) responsible with respect to polymer materials
and Anders Kinnander (772 5828) responsible for manufacturing part
The answers will be posted Monday, May 31st (studieportalen).
The results of the exam will be available via studieportalen.
Checking (*granskning*) of the corrected exams: Tuesday, June 29th, between 10:00 and 11:00h at the department (Rännvägen 2A) and on one occasion in the beginning of September (exact date will be posted on the course webpage (studieportalen) **Written requests for revision of the correction must be handed in no later than September 15th, 2010.**

Questions:
First, please read all questions! Don't write long answers but always motivate them.
Please, give back all the pages, even this front page!

1. Atomic structure and intercrystalline bonding	3 P
2. Electrical properties	5 P
3. Mechanical properties	4 P
4. Phase diagrams	4 P
5. Metal cutting theory	4 P
6. Metal forming – sheet metal forming (plåtformning)	3 P
7. Metal forming - calculations	4 P
8. Metal cutting - Turning (Svarvning)	4 P
9. Unconventional machining metods	3 P
10. The character of polymers	6 P
11. The viscoelasticity of polymeric materials	5 P
12. Transitions	5 P
Σ :	**50 P**

Ranking :
3 ≥ 40 % (20 P)
4 ≥ 60 % (30 P)
5 ≥ 75 % (38 P)

Notice: During the exam a **type-approved calculator** (*typgodkänd räknare är tillåten*) and a English-Swedish dictionary (or the wordlist) is allowed. The periodic system and 3 pages with formulas are included in the exam handout **- nothing else is needed!**

Göteborg, May 26th, 2010

Good luck !! **Uta & all other teachers**

1. Atomic structure and intercrystalline bonding (3 P)

a) Name the four quantum numbers, what they describe and how they are related! (1,5 P)

b) Name the principal bonding types and describe them briefly! (1,5 P)

2. Electrical properties (5 P)

a) Make a sketch of the electronic band structure of a metal and a ceramic! (1 P)

b) Where to find the donor and acceptor level in the band structure? Sketch or describe briefly! (1 P)

c) The figures below illustrate the variation of electrical conductivity with temperature of different metals and of silicon. Explain the differences for the two types of materials. (2 P)

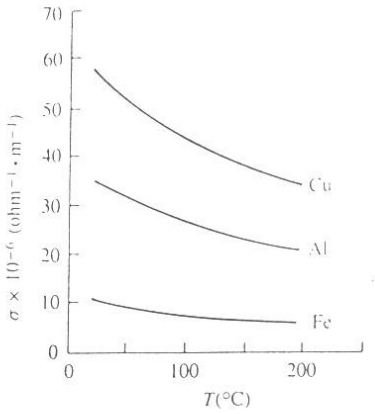


FIGURE 2 *Variation in electrical conductivity with temperature for some metals.*

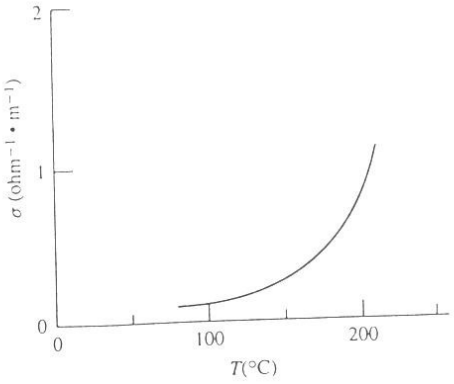


FIGURE 3 *Variation in electrical conductivity with temperature for semiconductor silicon.*

d) Considering a superconducting material (for example a ceramic), what is happening at the critical temperature? Motivate your answer! (1 P)

3. Mechanical properties (4 P):

a) Make a sketch of a stress-strain curve and explain with its help the following terms (mark them in the curve and explain what it is):

(i) yield strength (ii) tensile strength

(iii) ductility (iv) toughness (3 P)

b) Why is the stress-strain curve decreasing between the tensile strength and the point of failure? Describe briefly! (1 P)

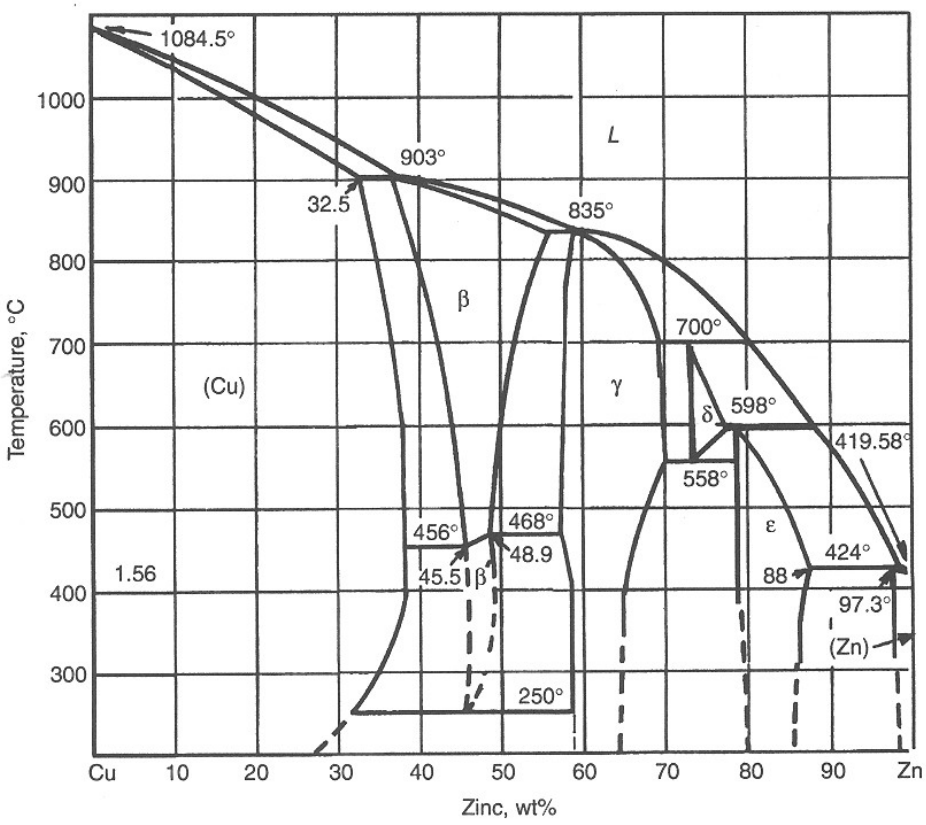
4. Phase diagrams (4 P)

a) Make sketches of the microstructure of Cu – 75 wt.% Zn

at (i) 750° C, (ii) 600° C, and (iii) 500° C. (1,5 P)

b) For Cu – 70 wt.% Zn at 400° C determine the phases present, their composition, and the phase amounts. (1,5 P)

c) What are the determining factors for solid solubility? Give three of them! (1 P)



5. Metal cutting theory (4 P)

Describe the effect of the different angels at a turning tool. Make also a drawing! (4 P)

6. Metal forming – sheet metal forming (plåtformning) (3 P)

Discuss in detail the method sheet metal drawing (dragpressning). What types of parts are made with the process, how are the dies (verktyg) arranged, what types of failures (fel/defekter) are possible, and how are these failures controlled or minimised? (3 P)

7. Metal forming - calculations (4 P)

In a cold forging operation the height of a cylindrical part is reduced by 30 % in the axial direction. (Vid en kallsmidesoperation av av en rund kuts är tjockleksminskningen 30%). The material follows Ludwiks' equation:

$$k_f = 200\phi^{0,32} \quad [N/mm^2]$$

a) The original yield strength (sträckgräns) of the material is 100 N/mm^2. How much is the yield strength changed as a result of the operation? (1,5 P)

b) You have a press with a maximum force of 100 kN. How large parts- what original (ursprunglig) diameter - can be forged in the press with the above deformation and material? (2,5 P)

8. Metal cutting - Turning (Svarvning) (4 P)

An axis with a starting diameter of 100 mm is turned (svarvas) to a diameter of 94 mm. The attack angle (ställvinkeln) is 90º. The engine power is 12 kW and the efficiency (verkningsgrad) is $\eta = 70\%$.

The specific cutting force equation is;

$$k_c = \left(750 + \frac{250}{h_D}\right)$$

a) The tool holder can resist a maximum load of 2000 N in the direction of the cutting speed. Calculate maximum feed (matning per varv). (1,5 P)

b) The Taylor equation for this material and tool (verktyg) is:

$v_c \cdot T^{0,35} = 412$

The tool changing time is 2 minutes. What cutting speed would you recommend if one wants to maximise the output (maximera produktionshastigheten)? You must in your answer take in to account the power of the machine. (2,5 P)

9. Unconventional machining metods (3 P)

Compare laser cutting and abrasive waterjet cutting of sheet metal (plåt). Think of the two processes' advantages and disadvantages. Make an as broad comparison as possible, but be especially sure to take into account applications and quality of the surface. (3 P)

10. The character of polymers (6 P)

For a full classification and characterization of polymers, several aspects on different structural levels need to be covered.

a) What four parts are generally needed for a full classification of a polymer? Also, explain briefly the substance of each part! Guidance: One of the four parts of classification concerns the size of the polymer chains. (4 P)

b) Describe with a schematic figure the general molecular weight distribution that can be expected for a typical conventional thermoplastic polymer! (1 P)

c) What are the two most common types of average molecular masses used for polymers? (1 P)

11. The viscoelasticity of polymeric materials (5 P)

When designing products made of polymeric materials, it is quite common to consider the time-dependence of mechanical properties. This type of time-dependence is generally called the viscoelasticity of materials.

a) What are the two types of basic viscoelasic behaviours generally involved when describing viscoelastic properties of a polymeric material? For each of the two basic behaviours, explain what is constant and what the measured time-dependence is! (2 P)

b) Give name and a simple equations describing the time-dependence of the material stiffness, for each of the two basic viscoelastic behaviours in a) above! (3 P)

12. Transitions (5 P)

Polymeric materials can in general have two types of thermal transitions.

a) For both types of thermal transitions, give names and describe what is happening on a molecular level when the transition temperature is passed at increasing temperature! (2 P)

b) For a semi-crystalline thermoplastic, describe with a figure how the stiffness is changing with increasing temperature! Here, the figure should include a temperature range that well includes normal application temperatures! Additionally, indicate and motivate the range of expected application temperature for solid products! (2P)

c) What is generally the stiffness of an amorphous thermoplastic at room temperature? (1 P)