Chalmers *Kursnr.: MMK072*
Material och tillverkningsteknik

Exam in Material och tillverkningsteknik-Z, January 14th, 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 Tuesday, January 15th (studieportalen).
The results of the exam will be available via studieportalen.
Checking (*granskning*) of the corrected exams: Thursday, February 4th, between 12:30 and 13:15h and Tuesday, February 9th, at the department (Rännvägen 2A). **Written requests for revision of the correction must be handed in no later than March 1st, 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 bonding in solids	5 P
2. Phase diagrams	6 P
3. Deformation and strengthening mechanisms	5 P
4. Thermal properties and failure	5 P
5. Unconventional machining methods	3 P
6. Metal cutting – milling (fräsning)	4 P
7. Metal cutting – theory	4 P
8. Plastic behaviour of metals	8 P
9. The character of polymeric materials	5 P
10. Mechanical properties of polymeric materials	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, January 11th, 2010

Good luck !! Uta & all other teachers

1. Atomic structure and bonding in solids (5 P)

a) Make a sketch of the potential energy versus interatomic spacing for two isolated atoms. Note on this plot the equilibrium separation and the bonding energy. (2 P)

b) Give the electron configuration of
(i) Oxygen (ii) Aluminum (iii) Scandium (iv) Titanium (1 P)

c) Describe what type of bonding exists within the water molecule and in NaCl. (1 P)

d) Give two important quantum-mechanical concepts associated with the Bohr model of the atom. (1 P)

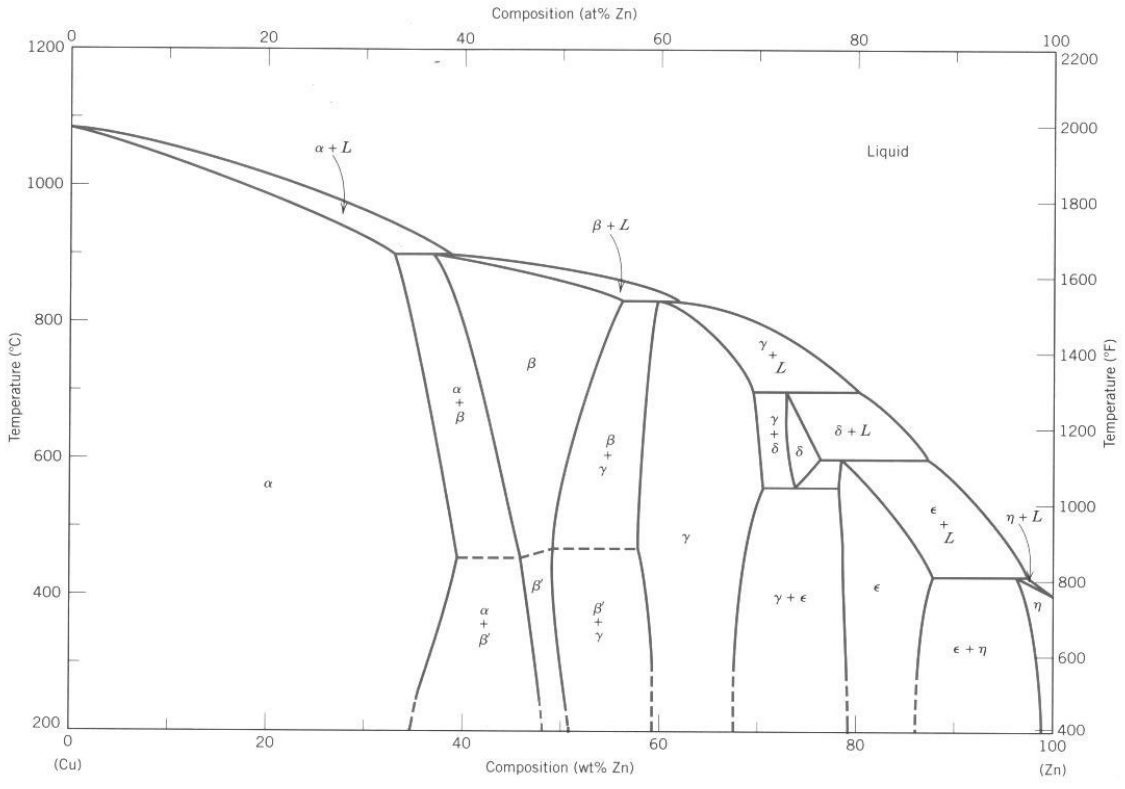
2. Phase diagrams (6 P)

a) Make a sketch of an eutectic phase diagram! (2 P)

b) Below, the Cu-Zn phase diagram is given. For Cu-71 wt.% Zn at 600°C and 500°C, determine which phases are present and their phase amounts. (2 P)

c) Make a sketch of the microstructure of Cu-71 wt.% Zn at 600°C. (0.5 P)

d) At Cu-50wt.% Zn the β' and β phase are present at low and at high temperature, respectively.. These phases are of bcc structure and one is ordered while the other is disordered. Make sketches of the unit cells of β and β' and explain which one (ordered or disordered) exists at low/high temperatures and why. (1.5 P)



3. Deformation and strengthening mechanisms (5 P)

a) Explain how the grain structure of a polycrystalline metal is altered when it is plastically deformed. (2 P)

b) Makes sketches of how an edge dislocation is moving (glide or climb). (2 P)

c) Why is a metal having small grains stronger than one having large grains? (1 P)

4. Thermal properties and failure (5 P)

a) Which are the two principal mechanism of heat conduction in solids? (0.5 P)

b) Compare the relative magnitude of the two contributions for each of metals, ceramics, and polymeric materials. (1.5 P)

c) The outer skin of the space shuttle must deal with/survive extreme temperature differences. What materials properties are required in the protective tiles on the surface of the space shuttle? Name at least two properties! (1 P)

d) What are possible failure mechanisms which can occur in electrical circuit boards? Name and briefly explain 4 of them. (2 P)

5. Unconventional machining methods (3 P)

a) Explain briefly the pump technology normally used for waterjet cutting. How is the high pressure created? Make a sketch. (2 P)

b) How are abrasives added in the jet for so called abrasive waterjet cutting? Make a sketch. (1 P)

6. Metal cutting – milling (fräsning) (4 P)

A slot with a width of 20 mm and a depth of 5 mm is milled with a 4 teeth milling cutter and a diameter of 20 mm. The power of the milling machine is 2,5 kW and the efficiency is 80%. The specific cutting force is described in the equation below:

$$k_{cm}=720+300/h_m$$

Calculate the maximum feed-speed and the cutting speed if the tool supplier specifies the maximum feed per tooth at 0,3 mm/tooth (at this depth of cut and in this material). The entrance angle of the milling cutter is 90º. (4 P)

(Ett 20 mm brett och 5 mm djupt spår ska fräsas med en 4-tandad pinnfräs med diametern 20 mm. Fräsens märkeffekt är 2,5 kW och verkningsgraden 80%. Materialets specifika skärkraft beskrivs av ekvationen. Bestäm max bordmatning och resulterande skärhastighet om fräsverktygstillverkaren anger att max matning per tand är 0,3 mm/tand (för detta skärdjup och detta material). Ställvinkeln för fräsen är 90º.)

7. Metal cutting theory (4 P)

a) Which are the two most important tool materials? (1 P)

b) Which three properties are the most important for tool materials? (3 P)

8. Plastic behaviour of metals (8 P)

Describe shortly plastic behavior of metals by answering the following:

a) Describe shortly with a clear sketch two simplifications of the k_f-curve. (1 P)

b) What does one mean with the recrystallization temperature? How high is it approximately for steel? (1 P)

c) Describe very shortly the most important principal differences between warm and cold metal forming when it comes too material behavior which is controlled by n. (1 P)

d) A material's deformation hardness behavior is well described with the above mentioned curve, which contains two material constants. One of the material constant is 0,29.

Your task is to in detail calculate the other material constant with three digit accuracy and in N/mm^2. A forging test with no friction involved is performed. A cylindrical work piece is forged to end height 18 mm with a maximum force of 300 kN from the hydraulic press. Starting geometry is diameter 20 mm and height 25 mm. (5 P)

9. The character of polymeric materials (5 P)

a) What general type of atoms can be found in conventional polymers? Also, explain the relation between monomer, mer and polymer! (1 P)

b) Explain schematically the four aspects needed when characterizing a polymeric material! Also, explain the terms used! (1 P)

c) Name the tree main groups of polymeric materials and the two subgroups of one of the three main groups! Also, explain the basic molecular structure of each of the polymer types! (1 P)

d) What transitions can be observed for polymeric materials and what happens at the transitions on a molecular level? Also, explain how do the transitions are limiting the applications of each of the main types of polymeric materials (all the types described in c above)? (2 P)

10. Mechanical properties of polymeric materials (5 P)

a) What types of stress-strain behavior can be regarded as typically for polymeric materials? Describe tree different typical behaviors with a schematic figure and name each behavior! (2 P)

b) What influences the different types of behaviors? Consider both external factors and factors related to the material character! (2 P)

c) Describe the viscoelastic response of a polymeric material to a step load, suddenly applied at time t1 and released later at t2! Answer with a schematic figure describing the deformation with time! (1 P)